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PLATES VI AND VII.

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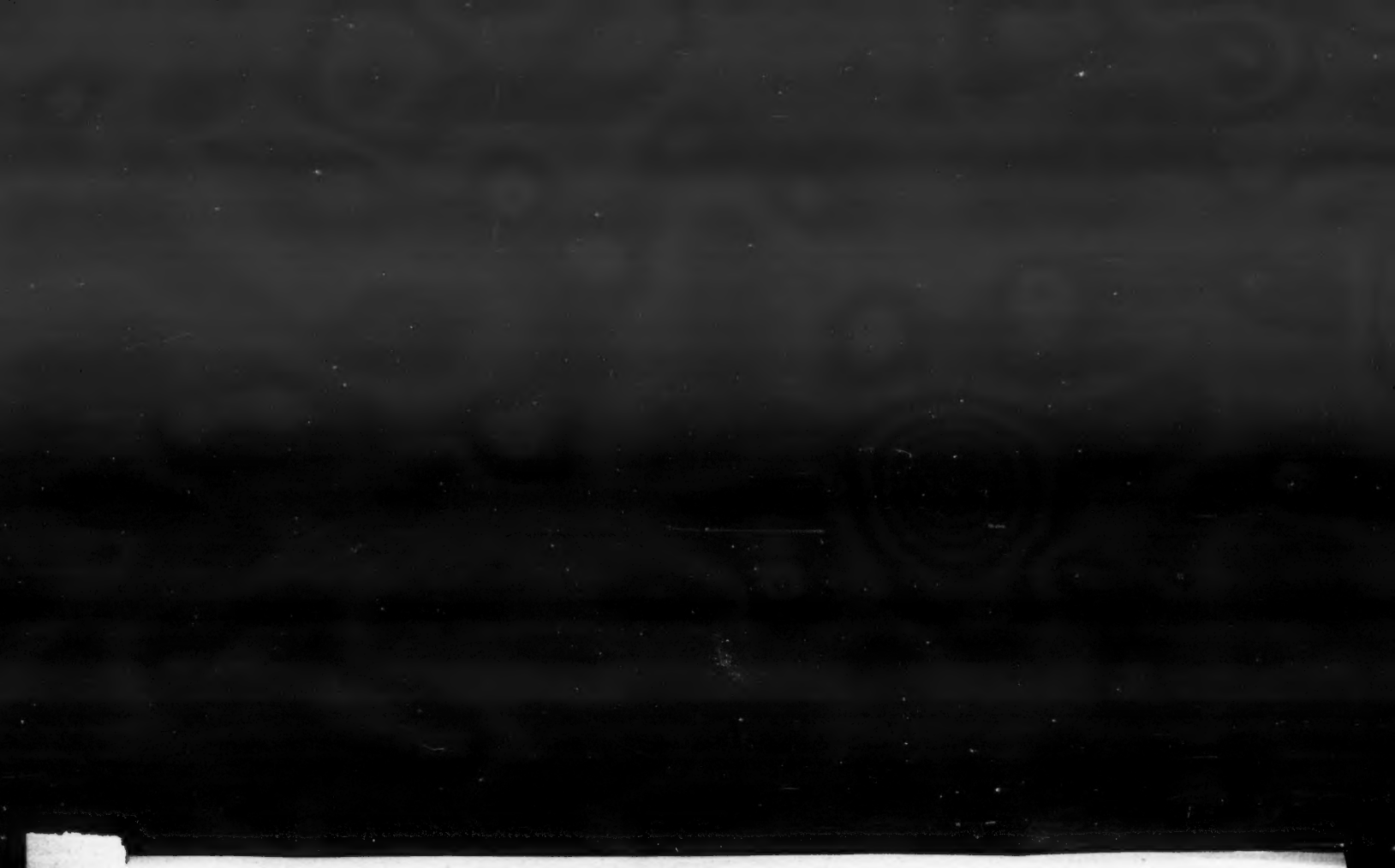


THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XL.—*Types of March Weather in the United States. The relations existing between mean atmospheric pressure, the prevailing character of the weather, and the paths of storms;* by OLIVER LANARD FASSIG. With Plates VI and VII.

Introduction.—It has long been recognized that the field of view of a national weather service is too small to study to the best advantage the daily weather phenomena as they pass over any one country.

In the past twenty years, several researches of great importance have appeared in which the field of investigation comprised large portions of the northern hemisphere, some of them indeed including both hemispheres. The results of these investigations show that the weather of a certain locality is intimately associated with atmospheric conditions very far removed from the immediate locality under consideration. For example, Hoffmeyer and Teisserenc de Bort have shown that certain conditions of pressure over the North Atlantic Ocean have a direct bearing upon the weather of Central Europe. Blandford and Eliot have demonstrated that certain marked phases of Indian weather find their explanation in pressure conditions in Central Asia and over the Indian Ocean. There are a few well-defined and persistent areas of high and low pressure of great extent in both hemispheres which control very largely the weather conditions of the globe. Recent researches tend to show that some of the attention heretofore given to transient cyclonic areas might well be diverted to the study of the so-called *permanent* high areas. The extensive areas of high pressure found upon any chart showing the mean monthly pressure conditions over the globe are real forces in

controlling the weather over wide areas. Any marked displacement of these areas from their normal or average position, or any unusual variation in the intensity of their gradients, is associated with unusual conditions of wind direction, temperature, and rainfall in their vicinity. The daily weather chart has made us all familiar with the kind of weather associated with the transient areas of high and low pressure which pass across the country every few days: with the clear skies and light, variable winds of a high area, the rainy unsettled weather near the center of low pressure. In interpreting the average weather conditions associated with the large persistent areas of average high or low pressure we find that the same rules apply as in the case of the transient areas based on synchronous observations.

In view of the slow movements of these areas of high and low pressure, their vastly greater extent and greater persistence, we have, for purposes of weather forecasting, an evident advantage over the method of following up the quickly moving cyclones and anti-cyclones of smaller extent, which may enable us to foresee the general character of the weather, for longer periods than we are now able to do.

A better knowledge of the movements of these "great centers of action," as M. Teisserenc de Bort calls them, would undoubtedly prove a valuable supplement to present methods in the practical work of forecasting. For example, should further investigation show that, when the pressure in the North Atlantic high area is above its normal value, and extends farther inland than usual, the paths of all storms, including the West Indian hurricanes which may arise during this time, are moved westward of their usual paths, we shall be able to determine much more accurately the probable paths of our storms.

In any event, since no material improvement has been made in late years in either the accuracy or the period of weather forecasts, it behooves us to give every encouragement to any suggestion which gives reasonable promise of advance, especially in the direction of forecasts for a longer period.

In the following pages a brief synopsis of the more important researches referred to above is presented in order to give a clearer conception of their nature and claims. I have attempted to follow a similar method of investigation in a detailed study of March weather conditions in the United States, with special reference to the Middle Atlantic States. An effort is here made to show that the weather east of the Rocky Mountains is largely controlled during March in its general characteristics by the relative development and the relative positions of the persistent areas of high pressure over the Atlantic Ocean and over Manitoba in British North

America. The study of conditions during March brings to light several interesting facts about the controlling factors in the weather east of the Rocky Mountains. An average pressure above the normal in the area of persistent high pressure over the Atlantic Ocean invariably brings to the Atlantic States mild ocean temperatures; an average pressure above the normal of the persistent high area over the interior of British North America as invariably brings to the Central and Atlantic States the cold air of the northwest. During a normal month of March the Atlantic States are alternately under the control of the high area in the northwest and that over the Atlantic Ocean, resulting in the changeable weather and strong contrasts in temperature so characteristic of March.

An intimate relation is also shown to exist between these pressure areas and the distribution and amount of rainfall, and in the paths of storms across the country.

Historical review.—Hoffmeyer, the eminent Director of the Danish Meteorological Service, as early as 1878 recognized the importance of securing observations over the widest field possible in the discussion of weather sequences.* It is to his efforts that the world is indebted for initiating in 1873 the excellent series of daily synoptic weather charts of the North Atlantic Ocean and Western Europe. He showed to what a great extent the winter conditions of Northern Europe are dependent upon the prevailing pressure distribution over the North Atlantic Ocean. He made a careful study of the origins and paths of storms over the Atlantic Ocean,† and pointed out how it would be practicable by joining Iceland, Greenland, the Azores and Bermuda, with neighboring mainlands by cable, to secure a daily weather chart sufficiently comprehensive to permit of making fairly accurate forecasts of the approach of storms, and to note carefully the pressure changes in the area of persistent high pressure in the neighborhood of the Azores.

The winter of 1879–80 was very severe throughout Central Europe; M. Léon Teisserenc de Bort,‡ of the Central Meteorological Bureau of France, made a careful study of the conditions which prevailed, and of the causes which produced them. In charting the mean monthly pressure over the North Atlantic and over Europe for the months of December, January and February, it was revealed that during December

* Distribution de la pression atmosphérique pendant l'hiver sur l'Ocean Atlantique Septentrional et influence que en resulte sur le climat de Europe. In Cong. intern. mét., Paris, 1878; also in Met. Zeitschr., Wien, 1878, pp. 337–347, 5 pls.

† Étude sur les tempêtes de l'Atlantique Septentrional. 4°. Copenhague, 1880. 47 pp. 4 pls.; also in Met. Zeitschr., Wien, 1880, pp. 345–361.

‡ Étude sur l'hiver de 1879–80. Annal. du Bureau Centr. Mét., Paris, vol. iv, 1881.

the area of high pressure, usually over the Azores, throughout the year, was during this month over France and neighboring regions; during a portion of January the area had resumed its normal position; again during February it was found over France. The normal distribution of pressure during the winter months gives to France a mild climate with prevailing southwesterly winds. During the presence over France of the area of high pressure, however, in December and February some of the lowest temperatures experienced during the present century occurred; the prevailing winds were northerly and much of the precipitation was in the form of snow and not in the usual form of rain. Further study of mean pressure conditions over the globe for a long series of years led M. Teisserenc de Bort to define and classify the different maximum and minimum areas of pressure which the atmosphere presents at the surface of the earth. These areas, which have a certain permanence in a given season and which are found on all charts of mean pressure, he designates "great centers of action of the atmosphere." Their existence is related to the position of the great centers of action of the globe, regions which either by their physical properties or by their orographic features initiate the great centers of atmospheric action, so-called because they govern the circulation of the winds all round them. These centers of action vary considerably from year to year, during the same month, in position and in extent. Their motion is not a regularly progressive movement in the well-defined direction made familiar to us in the study of the transient highs and lows of our daily weather map, but is irregular, a shifting from place to place—now to the north or south, then to the east or west, of an average position—following no law at present recognizable. It was shown that the character of a season is well defined when it is known what types of isobars prevail. Two important principles have been formulated by M. Teisserenc de Bort as a result of these studies:

1. When a region of a certain extent shows an excess of temperature either absolute or relative to the temperature of other points in the same latitude, there is a tendency to the formation of a minimum in that region, and an almost exact coincidence between the barometric minimum and the maximum of temperature; moreover there is a certain proportionality between them. This tendency is shown either by the existence of a closed minimum, or by an inflection of the isobars.

2. Areas of maximum pressure have a tendency to form in the neighborhood of regions where the temperature is low, either absolutely or relatively to their latitude.

The general circulation of the atmosphere due simply to difference in temperature between the equator and the poles, would produce a belt of high pressure around the globe near latitude 30° N. The differences of temperature which are produced over the globe between neighboring regions, and especially between continents and seas in the same latitude, by changing the density of the lower strata of the atmosphere, destroy the regularity of the isobars (as observed in the southern hemisphere) and bring about the formation of closed areas of high or low pressure which break up the zones, as shown in the northern hemisphere. (See Plate VI.)

In these researches of M. Teisserenc de Bort we have the first indications of a method which may lead to long-range forecasts. Van Bebber* suggests that the barometric maxima owe their origin and life mostly to the upper air currents; so that the air masses which are carried up in certain regions, even in the high latitudes and in the lower atmosphere, go to build up the highs. The usual explanation, he maintains, that the barometric maxima are fed by passing depressions, does not suffice, and leads to many contradictions.

General Greely maintains† that "a study of the annual barometric fluctuations will reveal their intimate connection with the prevalent types of weather or climate, so that abnormal departures in certain regions will be recognized as dominating factors in producing, later in the season, abnormal weather conditions in other and quite distant sections of the world." That "annual atmospheric waves, with their crests and troughs, move over the northern hemisphere somewhat in the same manner as the waves of high pressure, known as cold waves, move throughout the winter months from the interior to the Atlantic seaboard."

Mr. Eliot,‡ the Meteorological Reporter to the Government of India, seems to have established:

1. That there are well-marked pressure oscillations of long period over the Indian area.

2. That they are directly related to the largest and most important features of the weather in India, viz: the character and distribution of the precipitation of rain and snow in the Indian monsoon area.

3. That they are also directly related to the great atmospheric movements over India.

* J. van Bebber, Typische Witterungserscheinungen. Archiv der deutschen Seewarte, v. 1882. 4°. Hamburg, 1882.

† International pressure and storm charts. Report of Chief Signal Officer for 1891. Washington, 1891, page 750

‡ J. Eliot, A preliminary discussion of certain oscillatory changes of pressure of long period and short period in India. Indian Met'l. Mem., vol. vi, part ii, Calcutta, 1895, page 117.

Hildebrandsson* finds that the barometric variations about the Azores and about Iceland are nearly always opposed. That the same is true of the variations in Siberia and Alaska. That there exists a sort of oscillation in the pressure of the air between a center of action of high pressure and another neighboring one of low pressure. In comparing, on the other hand, the curves for the Azores and for Siberia, he finds a remarkable agreement. The variations at Key West do not accord with those in the Azores, but are in accord with those at San Diego. The departures of the same sign nearly always cover very large areas.

According to Major Rawson,† the so-called permanent areas of high pressure in the northern hemisphere do not have a steady progressive movement, but shift to one side or another about a fairly well-defined average position.

Poincaré‡ has in recent years presented to the French Academy of Sciences many communications upon the probable cause of these anomalous pressure changes, attributing them to the influence of the moon.

Thus we see that there is abundant testimony to establish the existence of well-defined larger movements of the atmosphere, which differ in extent and character of movement from the transient high and low areas pictured upon our daily weather maps; also that these movements have a direct and important bearing upon local climate. Leaving the historical side of the question, we come to the consideration of the positions occupied by these persistent areas of high and low pressure during March, and their influence upon local climates in the United States.

Average weather conditions during March.—In a study of weather conditions it is essential to bear in mind the "law of winds" announced independently over fifty years ago by our own countryman William Ferrel, and by Buys-Ballot of Holland: where there is a difference of pressure between neighboring regions on the same level the air will flow out of the region of high pressure into the region of low pressure. Owing to the revolution of the earth about its axis the flow of air will not be along straight lines, but along lines constantly bending to the right of the initial direction in the northern hemisphere; to the left in the southern hemisphere. The daily weather chart issued by the United States Weather Bureau has made us familiar with such systems of wind circulation as they pass across the country every few days, and has

* Quelques recherches sûr les centres d'action de l'atmosphère. Stockholm, 1897.

† Anticyclonic systems and their movements, Quart. Journ. Met. Soc., London, vol. xxiv. 1898.

‡ See Compt. Rend., Acad. Sci., Paris, 1889 et seq.

enabled us to see why the winds at any given place change rapidly in direction as an area of low or high pressure passes over the place. It is also essential to bear in mind certain relations existing between temperature and moisture conditions of the atmosphere. At a given temperature the maximum amount of invisible moisture in a given space is a fixed quantity. Should the temperature be lowered, some of the moisture will assume a visible form such as cloud or rain. Conversely, if the temperature be raised the space will become dryer as the capacity for moisture is increased by raising the temperature. Hence a portion of atmosphere rising from the surface of the earth will become relatively more moist as it rises, owing to the decrease in temperature upward from the surface. As the atmosphere contains at all times more or less moisture, a rising current will produce clouds and eventually rain, while a descending atmosphere becomes relatively dryer as it descends.

Now let us apply these simple laws to conditions in areas of low and high pressure. In a low pressure area we have seen that the atmosphere flows in toward the center from all directions, consequently at or near the center of the area it must rise and be lowered in temperature; the moisture of the atmosphere will approach saturation; clouds will be formed and if it continue to rise rain will follow. Hence an area of low pressure is apt to be characterized by cloudy and rainy weather. The atmosphere in a region of high pressure descends; hence it grows warmer as it descends. As it grows warmer, it becomes dryer; any clouds which may have existed over this area tend to become dissolved. Hence an area of high pressure is an area of clearing or clear weather. We shall see later that these principles hold good for average pressure conditions as well as for the transient conditions shown on our daily weather maps. That is to say, if in a certain region we find the mean pressure for the month to be considerably higher than in neighboring regions, the weather there will be found to be generally fair; while in a region where the pressure has been relatively low the prevailing weather will be found to be cloudy and unsettled. We can now see that if we can definitely locate areas of mean high pressure and mean low pressure, during a specified time, we shall have a means of determining readily the prevailing direction of the winds, this, in turn, enabling us to determine roughly the temperature and the rainfall.

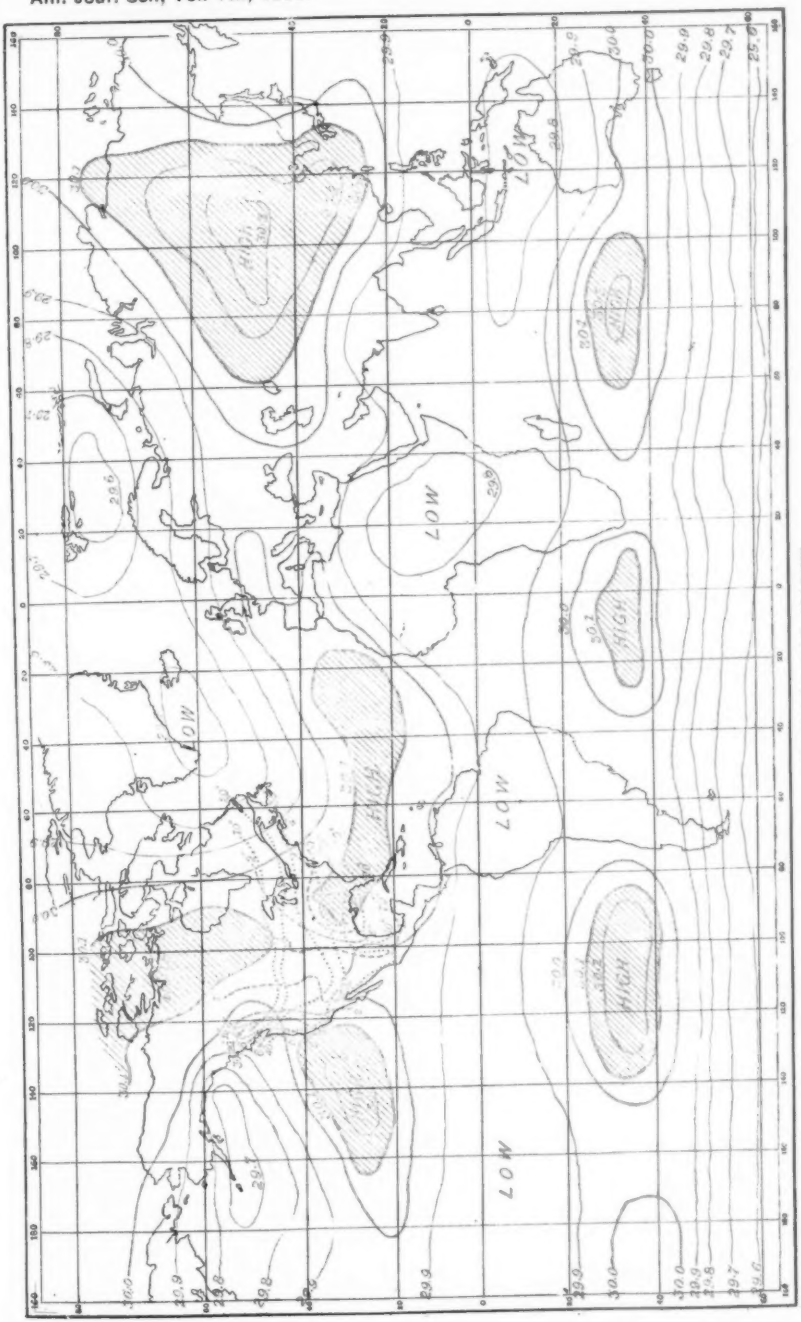
Throughout this discussion I have considered the isobar of 30·1 inches as defining roughly the outer limit of a high area, and the isobar of 29·9 inches as enclosing the area of low pressure.

This division into high and low areas has been uniformly maintained for convenience. These limits were adopted as the mean atmospheric pressure at sea level is approximately 30·0 inches; any area above 30·1 inches is consequently safely above normal, while any area below 29·9 inches is safely below normal.

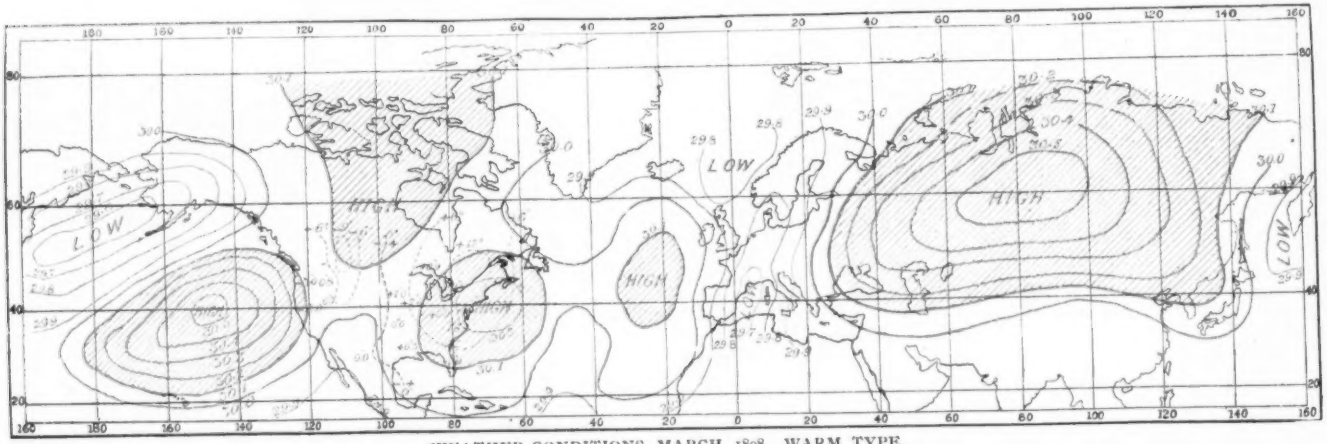
The characteristic features of pressure distribution during March in the northern hemisphere are as follows: a large area of excessively high pressure (see Plate VI) prevails over Asia. In the western hemisphere there are three well-defined areas of high pressure: one over British North America, another extending across the North Atlantic at about the latitude of thirty degrees, from the Azores westward, the third in the Pacific Ocean between California and the Hawaiian Islands. This triple arrangement of the areas of high pressure about the United States during March plays a most important part in determining the character of the weather. The areas of low pressure in the extreme northern portion of the Atlantic and Pacific Oceans are well developed and clearly defined.

March is proverbially a windy month, with strong contrasts and rapid changes in temperature. It is a transitional month, during which there is a breaking up of winter conditions and a beginning of summer conditions. The Middle Atlantic States (see Plate VI) lie between the normal March isotherms of 25° and 45°, though the mean temperature varies greatly from year to year. At Baltimore, where the normal March temperature is 42°, the values have varied from 35° to 49° during the past thirty years. The rainfall east of the Rocky Mountains attains a maximum of from five inches to seven inches in the eastern Gulf States and diminishes steadily to the west and north to about one inch over the Rocky Mountain plateau. Storms are frequent, and their paths across the country evenly distributed from the Lake region to the Gulf (see fig. 1, p. 335).

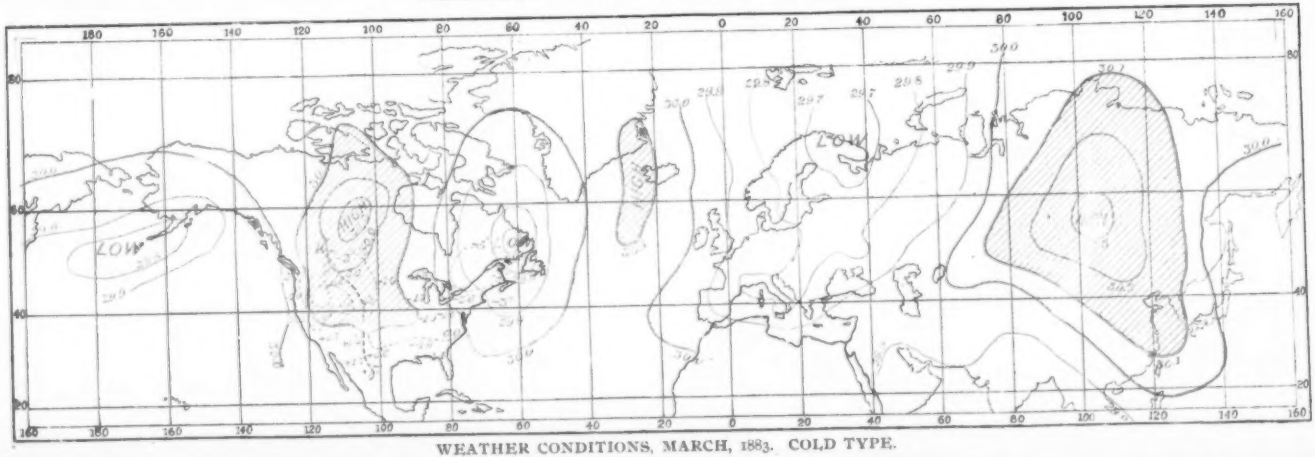
March, 1898.—See Plate VII. The month of March, 1898, was excessively warm in Maryland and Delaware; at Baltimore the daily excess of temperature was over seven degrees. There was but one short period of frost and this was free from injurious effects upon crops in these States. There were but few high winds and none of them destructive. The month was balmy and almost devoid of the usual stormy March winds. The rainfall, while somewhat below the normal, was sufficient to supply all the needs of growing crops. Crop correspondents of the United States Weather Bureau in Maryland and Delaware reported vegetation at the close of the month from three to four weeks in advance of the average season.



NORMALS FOR MARCH.



WEATHER CONDITIONS, MARCH, 1898. WARM TYPE.



WEATHER CONDITIONS, MARCH, 1883. COLD TYPE.

In looking for an explanation for the unusually warm spell of weather, it is found necessary to go far beyond the limits of these States. Reference to the Climate and Crop Report of the Weather Bureau for this month showed that the temperature was above the normal in all sections of the country east of the 100th meridian, the largest excess being in southern Canada, where it reached twelve degrees. West of the 100th meridian the temperature was everywhere below the normal, in Montana the departure being minus nine degrees. According to the United States Monthly Weather Review, the pressure was above normal from the Mississippi River eastward to the Atlantic coast, also on the northern slope and the north Pacific coast. It was below normal over California, the southwest, the Rocky Mountain regions south of Idaho and the plains from the Gulf of Mexico to the British possessions. The pressure was unusually high for the season over New England and the Canadian maritime provinces. The areas of high pressure of the month in most cases followed the northern track and persisted for several days over New England. The low areas in the majority of cases moved from the southwest to the lake region, then easterly north of New England. As a result the prevailing winds were southerly, giving fair weather and abnormally high temperatures to all of New England. The dividing line between southerly winds on the one hand, and northwesterly winds on the other extended northeasterly from Denver to Duluth, a position considerably farther to the northwest than usual. The winds of the Pacific coast were almost invariably from the northwest, while those of the mountain and plateau region were generally southwesterly. The rainfall was below the normal in the Atlantic coast and east Gulf States, and also in all the Pacific coast States; it was abundant in the Ohio and Mississippi Valleys.

In order to get a more comprehensive view of the situation, the pressure conditions prevailing over the entire continent, so far as observations could be gathered, were charted. Observations of mean atmospheric pressure were, at the same time, charted for the entire northern hemisphere so far as material was available, in order to study the situation in its broadest relations. The result is shown on Plate VII.

Looking at the pressure conditions over the North American continent and the neighboring oceans, and bearing in mind the principles referred to in the preceding paragraphs relating to wind and weather conditions in high areas and low areas of pressure, the abnormal weather conditions during March find a ready explanation.

The area of high pressure over the Atlantic which usually

extends from the Azores westward to Florida (see Plate VI) was, during March, 1898, materially modified in form and extent: it was found to be divided into two segments with the western segment unusually developed and enlarged. Over the entire eastern section of the United States and Canada the weather was under the control of a high area of exceptional strength for the season and the place, which brought to these regions either light variable winds or southerly winds. During the entire month ocean conditions prevailed, that is, the temperatures were equable in the main, and the regions were mostly free from the usual incursions of the cold continental weather conditions from the northwest. The low temperatures of the North Pacific coast find a similar explanation in the position and development of the high area in the north Pacific. The normal position of the Pacific Ocean high area brings to the North Pacific coast a mild, southwesterly wind. During March, 1898, this high area was found farther to the north and at the same time having greater energy than usual, thus bringing a colder northwesterly wind to these regions.

A glance at the chart will show that the high area over British North America was about normally developed and exerted no abnormal influence upon the temperature of the neighboring regions.

An abnormal distribution of pressure is also shown over the eastern North Atlantic and over Central Europe. Let us examine the records to see whether this departure in pressure distribution was accompanied by abnormal weather conditions in accordance with this distribution of pressure. Again examining Plate VI and bearing in mind the law of winds, we see that the prevailing winds over central and eastern Europe are from the southwest, bringing with them mild ocean temperatures and frequent rains.

During March, 1898 (see Plate VII) a segment of the Atlantic high area was found considerably to the north of its usual position, while a trough of low pressure existed over Central Europe. This distribution of pressure gives to the coast regions and to England northerly winds with low temperatures and precipitation in the form of snow. To Central Europe it brings southeasterly winds with rains, the direction of the wind being largely controlled by the excessively developed Siberian high area. Quoting from the Weekly Weather Review of the London Meteorological Office, we find that "with the exception of a few mild days about the middle of the month the weather of March was generally cold and changeable with frequent showers of snow or sleet. . . . . Until the concluding week very few depressions of importance were observed in the immediate neighborhood of our islands,

the centers of the large Atlantic disturbances keeping as a rule well away to the northward. Winds varied considerably but were mainly from the west in Scotland and from the north or northeast in England and Ireland."

Crossing the channel into France, we find that the weather was generally cold, being 3° below the normal at Paris. The dominant winds were from the northeast with prolonged rains. Snows were more frequent than rains in the northwest and the north of Europe, according to the monthly bulletin of the French Meteorological Bureau. From "Das Wetter" for March, 1898, we learn that the weather of central Europe was of a kind generally associated with low areas; cloudiness was far above the average, the rainfall was generally above the normal. Temperatures varied, being above in some sections and below in others, on the whole not deviating far from the normal.

In a method similar to that just described, pressure conditions were charted for the month of March for all years from 1877 to 1899; where observations were available, isobars were drawn for the entire northern hemisphere, but the investigation of weather conditions was confined to the United States, with special reference to the Middle Atlantic States. Having drawn the isobars, the departures from normal temperature and rainfall were entered upon the same chart. The months were then classified according to the departures from the normal temperature, in order to learn what relations existed between the distribution of pressure and the temperature departures.

The mean temperature of March was found to be decidedly above the normal during the years 1878, 1882, 1894, and 1898 in the Middle Atlantic States.

Warm Marches: March, 1878.—The temperature was excessively high in all portions of the United States and Canada, with a maximum departure of +20° over Manitoba; from this center the departures gradually diminished to 4° or 5° on the Atlantic and Gulf coasts and to 3° or 4° on the Pacific coast. The striking feature about the pressure distribution was the total absence of the high area usually over British North America, at least up to 60° north latitude. In the central portion of the United States, where the pressure usually averages about 30·0 inches, it was below 29·9 inches, causing a well-developed barometric depression. This distribution of pressure caused prevailing winds to blow into the central portion of the country from the Atlantic Ocean, the Gulf, and from the Pacific Ocean. The Atlantic high area, while only normally developed in its western extension, practically controlled the wind directions and temperatures over a great extent owing to the absence of the British high. The precipi-

tation was deficient east of the Mississippi River and south of the Lakes.

March, 1882, fig. 3.—During this month the temperatures were from 2° to 4° above normal in nearly all sections east of the Mississippi River; to the west and northwest they were from 4° to 8° above. The pressure distribution was totally different from that of March, 1878, but the eastern half of the country was again plainly under the influence of the Atlantic high area; this was not only unusually strong but extended inland far beyond the average limits. All the characteristics of high area weather prevailed in the eastern and southern states during the month; high temperatures, light winds, and comparatively dry weather. The northern high area was well developed but the center was farther to the north and east than usual, and not in a position to throw detached masses of cold air into the United States. Without observations to fix the position of the Pacific high, it is difficult to discuss intelligently the control of weather on the Pacific coast.

March, 1894.—The temperatures ranged from normal along the 105° meridian to 9° above in the Lake regions and to 3° below westward to the Pacific coast, again showing a decided control of the country east of the Mississippi by the Atlantic high area. The rainfall was deficient almost throughout the area enclosed by the isobar of 30·1 inches.

It is clearly apparent from a study of the foregoing analysis that in each case the eastern half of the country was under the domination of an extension of the Atlantic area of high pressure, which gave to this region either prevailing southerly or easterly winds from a warmer region, or prevailing light, variable winds. It will also be noted that when a region is clearly within this high area, generally within the isobar of 30·1 inches, there is a deficiency of rain, even when easterly winds are indicated by the arrangement of the isobars.

We see that the Middle Atlantic States and neighboring regions may be warmed owing to an unusual extension westward, or increased intensity of the Atlantic high area, as in 1882, 1894, and 1898; or it may be owing to the retreat northward of the British American high area, as in 1878. In either case there is a comparative absence of the cold northwesterly winds which are a characteristic feature of the normal March, in which there is more or less of a see-saw between the domination of winds from the northwest and those from the southeast. All warm Marches fall into one or the other of these two classes.

Cold Marches.—We come now to the consideration of another class of March conditions, those having mean tem-

peratures decidedly below the normal in the Middle Atlantic States.

March, 1883, Plate VII.—An examination of the chart will show a large area, everywhere east of the 105th meridian, in which the temperatures were below the average. The departures were not large but were uniformly below the normal east of this meridian, and as uniformly above normal from this meridian to the Pacific coast. The striking feature of the pressure distribution was the strength of the continental high area, together with the lack of development of the Atlantic high area in the western portion of the ocean. Such a system brings prevailing northerly or northwesterly winds to all sections in the eastern half of the country. The mild weather resulting from high pressure over the western Atlantic Ocean was absent. The cold and dry northwesterly winds meet with comparatively little opposition in their passage across the country, such as they meet with when the Atlantic high is well marked; there is a deficiency of rainfall, as is distinctly shown by the figures.

March, 1885, fig. 4. — In March, 1885, the line of temperature departure was again in the region of the 100th meridian, with decided minus departures eastward to the Atlantic Ocean and plus departures westward to the Pacific Ocean. The continental high area covers the entire country, with its greatest development over the northern plateau region, considerably to the south of its usual position. Here again the Atlantic high falls short of extending its influence to our coasts; while well developed it is found farther eastward with its axis inclined from southwest to northeast. The continental high again plainly dominates the weather of the United States. The fact that the center of the continental high area is so much farther to the south of its usual position is sufficient explanation to account for the temperatures above normal west of the 100th meridian. With this position of the center the bodily transfer of cold air from the neighborhood of Hudson's Bay does not take place, and hence there would not be the usual frequency of cold northerly winds.

March, 1888.—During this month temperatures were below normal throughout the United States and the Canadian provinces. In Manitoba the departure was minus ten degrees. From this point the departures diminished in all directions to the east, south, and west. In the Middle Atlantic States they were from 3° to 4° below; on the Pacific coast, temperatures were nearly normal. An area of high pressure of unusual intensity covered the greater part of British North America, the pressure over a large portion of this area reaching 30·3 inches. Over the Atlantic Ocean the high area is normally developed

both as to its form and intensity, but is found fully ten degrees farther south than its usual position. These two high areas are joined over the United States, giving the Atlantic Ocean high area the appearance of a prolongation of the continental high area; the latter, however, both on account of its great extent, and its steep gradient, clearly controls the situation, throughout the continent. The rainfall was nearly normal in all sections of the country, excepting in the western Gulf States, where there was an excess of about two inches. The permanent low area in the North Atlantic is found fully 20° south of its normal position. Central Europe is found in the center of this depression with all the characteristics of "depression weather."

March, 1891.—In this month we find the average temperatures again below the normal in all portions of the United States. The departures are nearly normal along the Atlantic and Pacific coasts and increase towards the 100th meridian, along which the departures reach minus eight degrees to minus ten degrees. The continental high area extends considerably beyond its normal eastern limit, with approximately normal intensity. Observations were not available to fix the position of the Atlantic high area, but at least its western extremity was but slightly developed, as there is no evidence of it in the pressure observations of the South Atlantic States. The rainfall of the month was nearly normal, excepting in the Middle Atlantic States, the Ohio Valley, and the East Gulf States, where it was considerably in excess of the normal, and upon the Pacific coast, where it was somewhat below.

March, 1897, cold in the extreme northwest, fig. 2.—The temperatures are from 3° to 6° above normal in all sections east of a line running from Duluth to Amarillo, Texas; to the west of this line, the temperatures are all below normal with a maximum departure of minus twenty degrees north of Montana. So far as the eastern States are concerned this belongs to the warm type of March; as, however, the greater part of the country is below normal, and the temperatures in the northwest are phenomenally low, it is described with the cold types. Here we have both the continental high and the Atlantic high with a nearly normal development in intensity but extending somewhat beyond their usual limits. In strength they are apparently equal, the Atlantic high controlling the eastern half of the country and the continental high the western half. On the Pacific coast we find the high area with apparently a normal development but somewhat to the south of its usual position. In the neighborhood of Puget Sound there is a low area. This distribution of pressure on the Pacific coast, together with a fair development of the conti-

nental high area appears to be particularly favorable for the production of low temperatures in the extreme northwest, the low pressure near Puget Sound facilitating the transfer of cold air from the interior toward the coast. The rainfall was considerably above normal in the Mississippi and the Ohio Valleys and somewhat above on the Pacific coast; it was below normal on the Atlantic coast within the area enclosed by the isobar of 30·1 inches.

March, 1899, cold in extreme northwest.—The conditions were somewhat similar to those of March, 1897. The temperatures were slightly above normal east of a line running from Boston southwest to Amarillo, Texas; to the west and north of this line, temperatures were everywhere below the normal, the greatest departures being in Montana, where they reached the excessive value of minus twenty degrees. The continental high was strongly developed. Its influence was felt in nearly all sections of the country reaching eastward as far as the lower Lake region and southward to Texas, the normal development of the Atlantic high area checking the further extension of its influence eastward. The rainfall was excessive in the Ohio Valley and Tennessee, in New England and in California; it was deficient in the South Atlantic and Gulf States, and in the neighborhood of Puget Sound.

The months cited above include all those during which there was a marked mean temperature below the normal east of the Mississippi River from 1876 to 1899, and two of extreme departures in the northwest. A characteristic feature of the former is a marked development of the continental high area, or a weak development or absence of the Atlantic high area in the region of the South Atlantic States. Again we notice a deficiency in rainfall in nearly all cases in which the region is clearly within the high pressure area, though this is not so universally true as in the case of the Atlantic high. All these conditions of pressure distribution naturally produce winds prevailingly from a northerly or a westerly direction, which bring with them the severe temperatures of the interior of the continent.

Extent and Intensity of Cold and Warm Periods.—The geographical extent and the amount of departure from the normal temperature are indicated upon the charts. By charting the mean pressure distribution in connection with the lines of equal temperature departure, we see readily why one section of the country may enjoy mild weather while in a neighboring section the weather may be exceptionally severe. We see also that the entire country may at the same time have temperatures considerably above or below normal.

The relation between pressure and rainfall.—Some interest-

ing relations between rainfall and mean pressure conditions have come to light in this investigation. The decidedly cold, as well as the decidedly warm months, were deficient in rainfall. In each case, in the Middle Atlantic States, "high area" weather prevailed, the region being either well within the Canadian high area or well within the Atlantic high area.

The extent and persistence of these areas of high pressure over any region define the geographic limits and the duration of a drought. Should we be enabled, by further study of the problem, to learn the law of movement of these high areas, it will become a comparatively easy problem to forecast periods of drought and of abundant rains in the United States. A similar method is already practiced in India, with a fair measure of success, in forecasting the monsoon and the winter rains.

During months having a rainfall above the normal in the Middle Atlantic States, this region was almost always within a trough of average low pressure, or near the western or northern edge of the Atlantic high area.

Average pressure distribution and the paths of storms.—Some interesting and suggestive points are brought out by charting storm tracks in connection with the mean pressure distribution during the month, and comparing the results with the normal distribution of pressure and storm paths.*

Fig. 1 shows the normal storm tracks during March. As has already been pointed out, during March the continental high and the Atlantic high areas are, within the limits of the United States, quite equally balanced in strength. It will be observed that the storm paths while normal pressure conditions exist, are spread quite uniformly over the country from the Great Lakes to the Gulf, and converge in the neighborhood of Labrador on leaving the United States. I have plotted the storm paths of March in connection with the pressure distribution during several characteristic abnormal departures of pressure. In fig. 2 for March, 1897, they are found in a narrow band extending east and west across the Lakes and down the St. Lawrence Valley. Fig. 3 for March, 1882, shows a crowding together of the storm paths into a comparatively narrow band, extending from northeast to southwest, across the Lake Region and down the St. Lawrence Valley. In fig. 4 for March, 1885, the paths are mostly north of their usual position, with some along the Atlantic coast, while the central portion of the country is comparatively free from storm paths.

Mean pressure distribution and the paths of West Indian hurricanes.—In order to learn whether the path of a West Indian hurricane is to any extent controlled by the prevailing

* F. H. Bigelow. Storms, storm tracks and weather forecasting. United States Weather Bureau, Bull. No. 20. 8°. Washington, 1897. 87 pp.

pressure over the Atlantic Ocean during the time of passage of a hurricane, I have selected from Bulletin A of the United States Weather Bureau the path of a hurricane which extended

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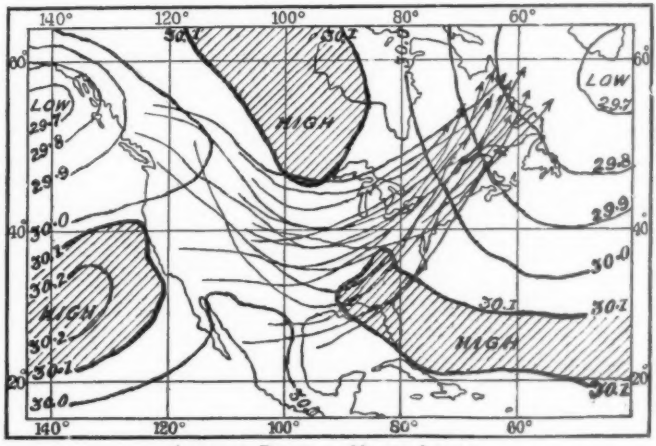

AVERAGE PATHS OF MARCH STORMS.

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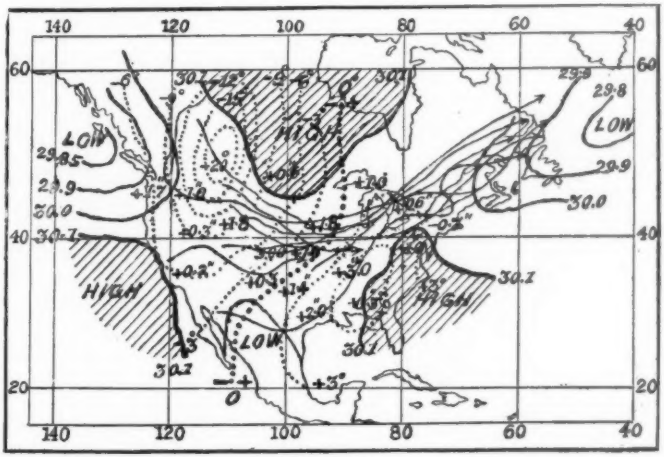

MARCH, 1897.

very far inland, and plotted it in connection with the mean September position of the Atlantic high area, together with the position of the area during September, 1886. This West Indian hurricane occupied about eleven days in its passage from

the West Indies through the Gulf of Mexico, up the Mississippi Valley and across the Lake region. The Atlantic high area extended far to the west of its usual position. Similarly the conditions for September, 1883, were charted, during which a

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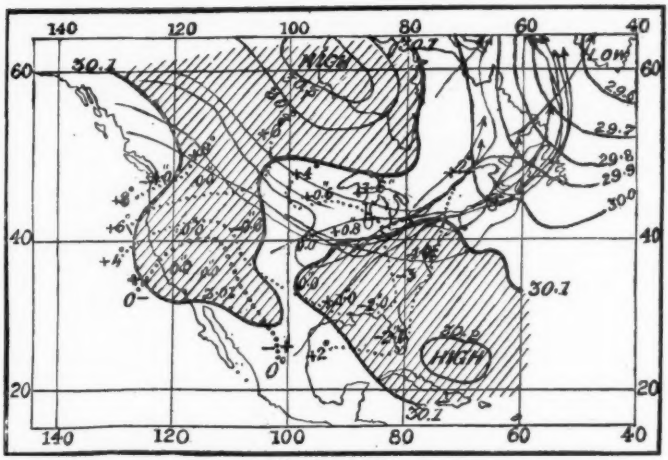

MARCH, 1882.

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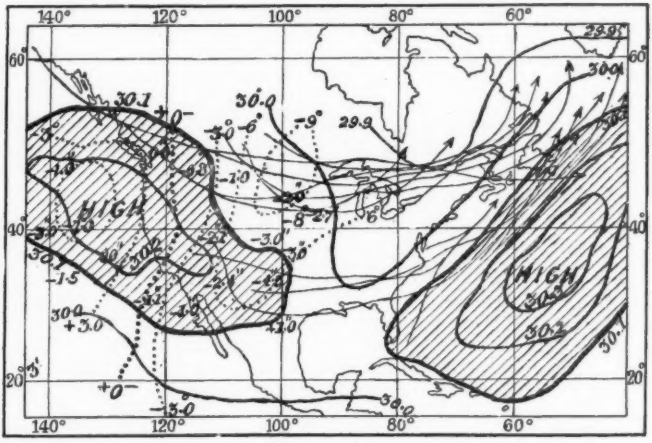

MARCH, 1885.

West Indian hurricane took a path farther to the eastward than usual. The Atlantic high area was well to the east of its usual position. In both cases the path of the hurricane was along the western edge of the Atlantic high area.

These two instances, taken at random, seem to show a direct relationship between the Atlantic high area and the path of the hurricanes. It is quite probable that by charting the pressure conditions over the Atlantic Ocean at the origin and during the slow progress of a hurricane, we may be enabled to forecast more definitely its probable path across the United States.

Summary of results.—The study of March weather conditions in the United States seems to warrant the following statements :

(*a*) The problem of March weather in the United States is a problem of the relative preponderance of the three areas of high atmospheric pressure seen upon the chart of normal pressure and described above.

(*b*) The weather of the Middle Atlantic States is cold when the continental high area controls this region; it is warm when the Atlantic high area extends its influence westward beyond the coast; it is normal when there is a fairly equal development in strength and extent of the two high areas, in which case now one, then the other, is in control of the wind direction, bringing alternately cold and warm air to the region.

(*c*) A complete control of the region by either area is accompanied by a deficient rainfall. The extent and persistence of the high area defines the extent and severity of a drought.

(*d*) The paths of storms lie within the trough between the two high areas; when the trough is wide the storm paths are widely scattered; as the high areas approach one another the storm paths are contracted within narrower limits.

(*e*) An intelligent discussion of Pacific coast weather demands a better knowledge of the development and movements of the Pacific high area. Under normal conditions during March the weather of the Pacific Coast States is completely controlled by this high area, which sends to these regions warm winds from the ocean. The temperatures and rainfall along the North Pacific coast are far in excess of the normal for those latitudes. An abnormal development of the continental high area will lower the temperature. This will be intensified by the retreat southward or westward of the Pacific high area, and the approach of the Behring Sea low area to the neighborhood of Puget Sound; a condition which brings about a comparatively steep gradient between the coast and the interior, and facilitates the transfer of large masses of cold air from the interior of the continent to the coast.

In order to turn to practical account the facts gathered in the foregoing paragraphs, a better knowledge of the manner in which these high areas move and their rate of movement, is

necessary. Excellent material is at hand for the study of these problems in the "Bulletin of Simultaneous International Observations" of the United States Weather Bureau, the "Synoptic Charts of the North Atlantic Ocean" of the Danish Meteorological Institute and the Hamburg Marine Observatory, and the "Charts of the Indian Monsoon Area" of the Indian Meteorological Service. It is of the highest importance to secure synoptic charts of the Pacific Ocean, charts for this vast area being at present entirely wanting. The United States Hydrographic Office has fortunately made a beginning in this direction by collecting daily observations of pressure, wind direction and state of the weather, for use in the preparation of the Pilot Chart of the Pacific Ocean, but these observations are not published and hence not easily accessible for purposes of study.

Some advance has been made in gathering telegraphic statistics for the North Atlantic since Hoffmeyer in 1879 proposed joining the islands of the ocean to the mainland in order to trace more accurately the larger atmospheric movements. In the south-western part of the ocean the chain has been completed by the recent establishment of the West Indian weather service as a branch of the United States Weather Bureau. Several most important links in the chain are still lacking, namely the Azores, Iceland and Greenland.

The necessity of a larger field of view in the study of weather sequences is steadily becoming more apparent to the meteorologist. The hope of progress in weather forecasting lies in this direction.

Johns Hopkins University, Baltimore.

ART. XLI.—*Some new Minerals from the Zinc Mines at Franklin, N. J., and Note concerning the Chemical Composition of Ganomalite;* by S. L. PENFIELD and C. H. WARREN.

THE minerals to be described in the present paper came for the most part from the one-thousand-foot level of the Parker Shaft on North Mine Hill. Unfortunately at the time that they were brought to the surface, about two years ago, the fact that several new species were being mined was not known, and a quantity of material, which it is believed would prove to be very profitable hunting ground for the new species, was thrown upon the dump and subsequently covered up. Our attention has been called to these minerals at different times by Messrs. E. P. Hancock, of Burlington, N. J., J. J. McGovern, of Franklin, F. L. Nason, of West Haven, Conn., F. A. Canfield, of Dover, N. J., and W. M. Foote, of Philadelphia, Pa., while both of the authors at separate visits to the locality have been able to collect a few specimens. The new species were found in a somewhat limited area, and it is especially interesting to note the minerals which are associated with them, for they are very unusual even for Franklin, N. J., and would seem to indicate that peculiar conditions prevailed during the period when these minerals were being formed. The associated minerals are as follows: Native lead* and copper,† clinohedrite,‡ roeblingite,§ axinite in transparent yellow crystals, willemite in exceptionally fine, transparent green crystals, vesuvianite, datolite, barite, garnet, brownish-black phlogopite and a little franklinite. The presence of axinite and datolite containing boron and of phlogopite would seem to indicate that the minerals, part of them at least, have resulted from metamorphism brought about by the action of intruded igneous masses either during the pneumatolitic period when such masses were giving off heated aqueous vapors carrying boron and fluorine compounds, or during a period when heated waters, laden with mineralizing agents, were circulating through the deposit.

1. HANCOCKITE.

This mineral was found in considerable quantity both massive and in cellular masses of a brownish-red or maroon color, and attention has already been called to it as a new species by Penfield and Foote in their description of clinohedrite.‖ Thus

* This Journal, vi, p. 187, 1898.
† Proc. Am. Acad. of Arts and Sci., xxxiii, p. 429, 1898.
‡ This Journal, v, p. 289, 1898.
§ Ibid., iii, p. 413, 1897.
‖ Loc. cit.

far it has been observed only in very small, lath-shaped crystals, the largest being not over 0·5^{mm} in length and 0·15^{mm} in diameter, and these generally are so intimately associated with garnet, axinite and phlogopite that it was for a long time difficult to secure a specimen from which a sufficient quantity of the pure material could be obtained for the chemical analysis. The accompanying figure is a sketch of one of the crystals as seen under the microscope. The faces are striated parallel to the longer axis of the crystals, and they round into one another owing to oscillatory combinations. The terminal faces, neces-

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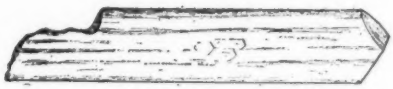

sarily very small, are vicinal, and it has thus far been impossible to find any crystal from which satisfactory measurements of the interfacial angles could be obtained. As may be seen from the figure the habit of the crystals is like that of epidote; that is, the prominent faces are parallel to the axis of symmetry, and the crystals are terminated by two faces corresponding to the form n ($\bar{1}11$) of epidote. On one of the crystals it was possible to obtain approximate measurements with the Fuess reflecting goniometer by using a strong illumination of the signal and the δ ocular. The measurements, given in the accompanying table, although not sufficiently accurate for establishing an axial ratio, indicate that the forms and angles of hancockite are similar to those of epidote.

	Hancockite, Approximate measurements.	Epidote.
$c \wedge e$, $001 \wedge 101$ =	36° 15′	34° 43′
$e \wedge a$, $101 \wedge 100$ =	30 45	29 54
$c \wedge r$, $001 \wedge \bar{1}01$ =	63	63 42
$r \wedge a$, $\bar{1}01 \wedge \bar{1}00$ =	55 30	51 41
$n \wedge n$, $\bar{1}11 \wedge 11\bar{1}$ =	67	70 29
$c \wedge n$, $001 \wedge \bar{1}11$ =	77	75 11

Although the appearance of the mineral in the hand specimen varies from a dark to a light brownish-red, single crystals, as seen with a pocket lens, have a yellowish-brown color. Crystals like fig. 1, when examined with the polarizing microscope, exhibit distinct pleochroism, yellowish-brown for vibrations parallel to b, which corresponds to the crystallographic axis b, and somewhat variable for vibrations at right angles to this direction, being delicate rose color at the attached end and

grading to pale, somewhat greenish-yellow at the terminated end. On some very small individuals the delicate rose color was observed throughout the whole length of the crystals. With crossed nicols the crystals show an extinction when their longer or symmetry axis is parallel to the plane of the polarizer. In convergent light something of the outer rings of the biaxial interference figure could be seen, accompanied by a dark bar, indicating plainly that the optical axes are in the symmetry plane. By rotating a crystal, when immersed in the potassium mercuric-iodide solution, the optical axes could be brought separately to the center of the field and their divergence 2 V was found to be approximately 50°.

The luster of the hancockite crystals is vitreous, and the hardness is about 6·5–7. Owing to the small size of the crystals and their intimate association with garnet, axinite and willemite, considerable difficulty was experienced in finding a specimen from which a sufficient quantity of pure material could be obtained for analysis. A specimen, however, finally came to us through Mr. Hancock, consisting of a cellular mass in which the walls and the drusy lining consisted chiefly of hancockite. By crushing this specimen, picking out the small fragments and examining them with a lens, it was possible to obtain the mineral almost absolutely free from the associated garnet and axinite, which could be distinguished by their lighter color. An attempt to separate the minerals by differences in their specific gravity was not successful. The specific gravity of the carefully selected material was found to be 4·030.

Concerning the method of analysis the only points which need to be specially commented upon are the following: After separation of the silica, the lead was precipitated with hydrogen sulphide and subsequently converted into sulphate and weighed. The iron and alumina were separated from the bivalent metals by a basic acetate precipitation, reprecipitated by ammonia and weighed as oxides, the iron being estimated subsequently by means of potassium permanganate. The calcium and strontium were converted into nitrates and separated by means of amyl alcohol as directed by Browning.* Water was estimated by loss on ignition. Careful tests failed to reveal the presence of any ferrous iron. The deep color of the crystals at first suggested the idea that the mineral would be rich in manganese, which is by no means the case. The color, however, is probably due to the presence of some higher oxide of manganese which is known to impart an intense color to silicates and was estimated by the method described by Penfield.†

* This Journal, xliii, p. 50, 1892. † Ibid, xlvi, p. 291, 1893.

The results of the analysis by Warren are as follows:—

			Average.	Ratio.				Partial Analysis.	
SiO_2	30·99		30·99	·516		SiO_2	6	SiO_2	30·88
Al_2O_3	17·89		17·89	·173	}			Al_2O_3	17·99
Fe_2O_3	12·30	12·37	12·33	·077	} ·259	R_2O_3	3·00	Fe_2O_3	12·96
Mn_2O_3	1·38		1·38	·009	}				
PbO	18.47	18·59	18·53	·083	}			PbO	17·47
MnO	2·12		2·12	·029	}			MnO	2·96
MgO	0·52		·52	·013	} ·367	RO	4·26	MgO	1·02
CaO	11·50		11·50	·205	}			CaO }	15·33
SrO	3·89		3·89	·037	}			SrO }	
H_2O	1·62		1·62	·090		H_2O	1·06		1·62
			100·77						100·23

The ratio of $SiO_2 : R_2O_3 : RO : H_2O$ approximates closely to 6 : 3 : 4 : 1, which gives as the empirical formula $H_2R''_4R'''_6Si_6O_{26}$, or $R''_2(R''' \cdot OH)R'''_2(SiO_4)_3$. The general formula is that of epidote, but the material differs from any variety of that mineral previously described in having the bivalent metals lead and strontium isomorphous with calcium. Owing to its color and the presence of manganese sesquioxide the mineral is allied to piedmontite. It will be observed that the quantity of protoxide, RO, indicated by the analysis, is a trifle high, $SiO_2 : RO$ being 6 : 4·26 instead of 6 : 4, as it should be to satisfy the epidote formula. The analyses, however, were made with very great care, and in the determination of the calcium and strontium the separated oxides were converted into sulphates and thus found to have the correct molecular weight. The partial analysis given was made on material taken from the same specimen as used for the other analysis, but the higher oxide of manganese was not determined and strontium was not separated from the calcium.

In its chemical as well as in its crystallographic relations, hancockite is a member of the epidote group of minerals, and should occupy a position next to piedmontite in a system of mineralogy. It is especially interesting on account of the considerable quantities of lead and strontium which it contains, elements thus far observed in combination with silicic acid in only a few rare mineral species.

Before the blowpipe, hancockite fuses with intumescence at 3 to a black, slightly magnetic globule. The globule becomes more strongly magnetic if heated on charcoal. With sodium carbonate on charcoal a coating of lead oxide is obtained. Reacts for manganese with the sodium carbonate bead in O. F. The mineral is insoluble in hydrochloric acid, but, like epidote,

after fusion it dissolves and yields gelatinous silica upon evaporation. In the closed tube, at a high temperature, a little water is given off.

A considerable quantity of hancockite was taken from the mine at one time, and it is the most abundant of the new species described in this paper. It is named after Mr. E. P. Hancock of Burlington, N. J.

2. Glaucochroite.

This mineral was collected by S. L. Penfield in September, 1898, and was subsequently sent to New Haven for identification by Mr. W. M. Foote, who had collected several specimens of it earlier in the season. It occurs in prismatic crystals belonging to the orthorhombic system, and in columnar aggregates imbedded in a white matrix. The largest crystals thus far observed do not average over 2^{mm} in greatest diameter, while the length of some of the columnar aggregates somewhat exceeds 10^{mm}.

Isolated crystals generally show the form of a prism m (110), sometimes in combination with a second prism s (120), and thus far all attempts to find a crystal with terminal faces have proved unsuccessful. A few penetration and contact twins have been observed, the twinning plane being the brachydome (011), and

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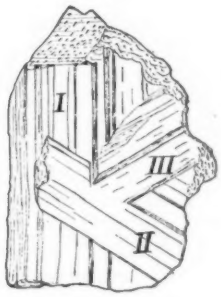


the vertical axes of the individuals crossing at angles of about 60° and 120°. Fig. 2 is an illustration of one of these penetration twins, drawn with the camera lucida as it appeared under the microscope. On the twin crystals the pinacoid a (100) is generally developed, although it was not observed on any of the simple crystals.

The prismatic faces, although bright, were vicinal, and consequently it was difficult to obtain reliable measurements of the prismatic angle. The average of a number of measurements

of $m \wedge m$, $110 \wedge 1\bar{1}0$, was found to be 47° 32′, and this angle, taken as fundamental, agreed very closely with the measurements derived from the best reflections. As terminal planes were not observed, the angle between the vertical axes of two prisms in twin position was measured under the microscope and found to be 121°. Assuming the twinning plane to be the brachydome (011), the angle of $011 \wedge 0\bar{1}1$ was thus found to be 59°, and taken as a fundamental angle. From the foregoing fundamental angles the axial ratio has been calculated, and is given below, together with the axial ratios of monticellite and chrysolite, to which species glaucochroite is closely related, it being a manganese monticellite.

Glaucochroite,	a	:	b	:	c	=	0·440	: 1 : 0·566
Monticellite,	"		"		"	=	0·431	: 1 : 0·576
Chrysolite,	"		"		"	=	0·466	: 1 : 0.586

No reliable reflections could be obtained from the second prism s (120). Approximate measurements are $120 \wedge \bar{1}20 = 99°$, calculated 97° 16′ and $m \wedge s$, $110 \wedge 120$, = 17° 21′, calculated 17° 36′. A rather poor basal cleavage was detected, and measurements from this cleavage onto the prism faces gave angles of 90°.

The hardness is about 6. The specific gravity, taken with the pycnometer is 3·407. The fracture is conchoidal. The luster is vitreous and the color is a delicate bluish green, very similar to that of the aquamarine variety of beryl. Minute crystals are almost colorless, and on a few of the specimens there were small areas where the mineral exhibited a delicate pink color.

The optical orientation is $a = b$, $b = c$ and $c = a$. The plane of the optical axes is the base (001) and the acute bisectrix is normal to the brachypinacoid b (010). The double refraction is therefore negative. Prismatic crystals served as prisms for determining the indices of refraction $\alpha = 1{\cdot}686$ and $\beta = 1{\cdot}722$. These values were each derived from the mean of four independent measurements which showed considerable variation, owing to the vicinal character of the prismatic faces, but it is believed that they represent a close approximation to the true values. On a section parallel to the pinacoid (010), which measured $0{\cdot}5 \times 1{\cdot}5^{mm}$, the divergence of the optical axes for yellow light, Na flame, was measured on the Fuess axial angle apparatus as follows: 2 E = 121° 30′ and 2H in α-monobromnaphtalene = 63° 27′. From these values $2V_y$ was found to be 60° 53′ and 60° 49′, respectively. The dispersion was marked $\rho > v$. From the values α, β and V, γ was calculated and found to be 1·735. The optical orientation, dispersion and

the character of the double refraction of glaucochroite are like those of monticellite as determined by Penfield and Forbes.* The indices of refraction for yellow light and the divergence of the optical axes, 2V, of glaucochroite, monticellite and chrysolite are given below for comparison:

	α	β	γ	$\gamma-\alpha$	2 V over α
Glaucochroite,	1·686	1·722	1·735	0·049	60° 51′
Monticellite,	1·6505	1·6616	1·6679	0·0174	75° 2′
Chrysolite,†	1·661	1·678	1·697	0·036	92° 14′

Very pure material for the chemical analysis was obtained by picking out the small prismatic crystals which separated readily from the matrix. The results of the analysis by Warren are as follows:

		Ratio.		Corrected analysis.	Theory for $CaMnSiO_4$
SiO_2	31·48	·524	1·00	31·98	32·08
MnO	38·00	·535	1·02	38·60	37·97
CaO	28·95	·517	·99	29·42	29·95
PbO	1·74				
FeO	trace			100·00	100·00
	100·17				

Leaving out of consideration the small amount of PbO, which, owing to its high molecular weight, had only a slight effect upon the ratio, the ratio of SiO_2: MnO: CaO=1·00: 1·02: 0·99, or a very close approximation to 1:1:1. The formula of glaucochroite is therefore $CaMnSiO_4$, that of monticellite being $CaMgSiO_4$. With the above analysis we have given the corrected analysis, after disregarding 1·74 per cent of PbO and calculating to 100 per cent, and also the theoretical composition corresponding to the formula $CaMnSiO_4$. Glaucochroite takes therefore a place in the system of mineralogy next to monticellite as a member of the chrysolite group.

Glaucochroite fuses quietly before the blowpipe at about 3·5 to a brownish black globule, and imparts no color to the flame. The powdered mineral dissolves easily in hydrochloric acid, and the solution yields gelatinous silica upon evaporation. A little of the concentrated solution, when brought in contact with a drop of sulphuric acid on a watch glass, gives a precipitate of calcium sulphate. With either the borax or sodium carbonate beads a strong reaction for manganese is obtained.

So far as known, only a small amount of glaucochroite has been found. Its crystals occur imbedded in a white matrix, nasonite (see beyond), and intimately associated with brown

* This Journal, 1, p. 135, 1896.

† Des Cloizeaux, Memoirs de l'Institute de France, T. xviii, p. 591.

garnet and yellow axinite. The name glaucochroite has been given to this species because of its color, from γλαυκός=*blue-green* and χροια=*color*.

3. Nasonite.

This material constitutes the matrix in which the crystals of glaucochroite are generally imbedded. It occurs massive, of white color, greasy to adamantine luster, hardness about 4, and hand specimens usually present a mottled or spotted appearance owing to numerous inclusions of yellow axinite and brown garnet, which are scattered rather uniformly through the massive nasonite. The material that has been examined consists of a few specimens collected by S. L. Penfield and some sent to us by Mr. W. M. Foote.

Thin sections when examined with the polarizing microscope show that the material is crystalline, and that the masses consist of an intergrowth of crystal particles, some of which are several millimeters in diameter. No pronounced cleavages were observed under the microscope, and no crystal boundaries were detected which gave any clue to the system of crystallization. In convergent polarized light, however, certain sections gave a uniaxial interference figure, and, since the massive mineral broke up at times into rude rectangular blocks, it may be inferred that the crystallization is tetragonal and that the cleavage, which is poor, is prismatic and basal. The birefringence is rather strong, and the character of the double refraction is positive.

Material for the chemical analysis was obtained by crushing a large fragment and picking out the purest material by hand. The specific gravity was found to be 5·425, and the results of the analysis by Warren are as follows:

	I	II	Average	Ratio		
SiO_2	18·47	18·47	18·47	·308		3·00
PbO	65·84	65·52	65·68	·294		
ZnO	0·84	0·80	0·82	·010		
MnO	0·90	0·76	0·83	·011	·516	5·03
FeO	0·10	——	0·10	·001		
CaO	11·20	11·20	11·20	·200		
Cl	2·80	2·82	2·81	·079	·108	1·05
H_2O	0·27	0·26	0·26÷9	·029		
			100·17			
Oxygen equivalent of Cl			·63			
			99·54			

The ratio of SiO_2 : (Pb+Zn+Mn+Fe+Ca) O : (Cl+OH) = 3·00 : 5·03 : 1·05 which approximates closely to 3 : 5 : 1, and, since two chlorine atoms are equivalent to one oxygen, this leads to the general formula $R_{10}Cl_2Si_6O_{21}$, R = Pb and Ca, and only traces of Zn, Mn and Fe. Before discussing the general formula further, it may be stated that there were observed, intimately associated with the nasonite, a few particles of clinohedrite, $H_2CaZnSiO_5$, and it is probable therefore that the small percentage of zinc (0·82 per cent ZnO) was derived from a slight admixture of this latter mineral. It seems therefore best to deduct from the foregoing analysis the ZnO, and sufficient amounts of SiO_2, CaO and H_2O to form the clinohedrite molecule. The ratio then becomes SiO_2 : (Pb+Mn+Fe +Ca) O : (Cl+OH) = ·298 : ·496 : ·098 = 3·00 : 5·01 : 0·99 or almost exactly 3 : 5 : 1. Furthermore the ratio of SiO_2 : PbO : (Ca+Mn+Fe) O : (Cl+OH) = ·298 : ·294 : ·202 : ·098 = 3·00 : 2·97 : 2·04 : 0·99 or, very closely, 3 : 3 : 2 : 1. Since Fe, Mn, and water (hydroxyl) are present only in very small amounts, they may practically be disregarded, and the empirical formula expressed as $Pb_6Ca_4Cl_2(Si_2O_7)_3$, or $Pb_4(PbCl)'_2Ca_4(Si_2O_7)_3$.

Below we have given the analysis, after deducting 2·16 per cent of clinohedrite, substituting for MnO and FeO equivalent amounts of CaO, for the remaining 0·09 per cent of water (hydroxyl) an equivalent of chlorine, and calculating to 100 per cent, while, for comparison, the theoretical composition corresponding to the formula $Pb_6Ca_4Cl_2(Si_2O_7)_3$ is also given.

	Analysis corrected.	Theory.
SiO_2	18·32	18·21
PbO	67·32	67·68
CaO	11·59	11·33
Cl	3·57	3·59
	100·80	100·81
O = 2Cl	·80	·81
	100·00	100·00

Before the blowpipe, nasonite is very apt to decrepitate, but if a fragment can be held in the forceps it fuses at about 2 to a semi-transparent globule, and the characteristic flame coloration of lead is obtained. In the closed tube the mineral gives a trace of water and an abundant sublimate of lead chloride, the residual mineral fusing to an amethystine glass in the bottom of the tube. The powdered mineral, when heated alone on charcoal in the reducing flame, gives a white sublimate of lead chloride distant from the assay, a yellow coating of oxide nearer,

and globules of metallic lead. The mineral is readily soluble in dilute nitric acid, and the solution yields gelatinous silica upon evaporation.

The mineral is named after Mr. Frank L. Nason of West Haven, Connecticut, formerly of the Geological Survey of the State of New Jersey.

Note concerning the Chemical Composition of GANOMALITE.

Nasonite is closely related to ganomalite, to which the empirical formula $Pb_3Ca_2Si_3O_{11}$ has been assigned, a little calcium being replaced by manganese. The foregoing formula, when doubled, may be written as a slightly basic salt, as follows: $Pb_4(Pb_2O)''Ca_4(Si_2O_7)_3$, which is like the formula of nasonite, except that the bivalent basic lead oxide radical (Pb_2O) of ganomalite takes the place of the two univalent lead chloride radicals (PbCl) of nasonite. The analogy between the two minerals, however, becomes still closer if two univalent lead hydroxide radicals (PbOH) are substituted for the bivalent basic lead oxide radical as follows: $Pb_4(PbOH)_2Ca_2(Si_2O_7)_3$, and we hope to be able to show that this is undoubtedly the correct formula for ganomalite. The amount of water necessary to yield two hydroxyls in the complex ganomalite molecule is a trifle less than one per cent, a quantity which might have been easily overlooked. In two analyses of ganomalite from Jakobsberg, Sweden, by Wiborgh, quoted by Sjögren,* neither water nor loss on ignition are recorded, while in an analysis by Lindström† a loss on ignition of 0·57 per cent is given, and, what is also very significant, the presence of a little chlorine is recorded. Lindström's analysis is as follows:

	Analysis.		Ratio.			Analysis recalculated.	Theory for $Pb_4(PbOH)_2Ca_4(Si_2O_7)_3$
SiO_2	18·33		·306	3·00	SiO_2	18·51	18.56
PbO	68·80		·308	3·02	PbO	69·46	68·97
MnO	2·29	·032			CaO	11·40	11·55
MgO	·11	·003	·202	1·98	H_2O	·63	·92
CaO	9·34	·167					
Cl	·24	·007	·070	0·70		100·00	100·00
Ign.	·57÷9=·063						
‡X	·35						
	100·03						

The ratio of $SiO_2 : PbO : CaO : (OH+Cl) = 3·00 : 3·02 : 1·98 : 0·70$ or, excepting the hydroxyl and chlorine, a very close approximation to 3 : 3 : 2 : 1, thus agreeing with the ratio of nasonite.

* Geol. För. Förhandl., vi, p. 537, 1883. † Ibid., p. 663.

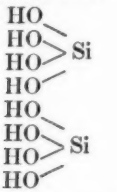
‡ X=CuO 0·02, Al_2O_3 0·07, Fe_2O_3 0·12, alkali 0·10, P_2O_5 0·04.

The water (loss on ignition) is low, owing undoubtedly either wholly or in part to the partial oxidation of the manganese during ignition. It is also possible that a trace of fluorine was present, since the amount necessary to bring the ratio of (OH+Cl+F) up to 1 would be trifling and might easily be overlooked. In connection with Lindström's analysis we have given his values recalculated to 100 per cent, after substituting an equivalent of CaO for the small amounts of MnO and MgO, an equivalent of water (hydroxyl) for chlorine, and disregarding the 0·35 per cent designated as X. The theoretical composition corresponding to the formula $Pb_4(Pb.OH)_2Ca_4(Si_2O_7)_3$ is also given, and, except for the water, which is 0·31 per cent low, the agreement between the recalculated analysis and the theory is most satisfactory.

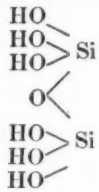
Ganomalite is tetragonal, and, in all probability, nasonite crystallizes in the same system, for, as already stated, the latter is optically uniaxial and breaks out into rude rectangular blocks, corresponding to the form produced by a combination of the prismatic and basal cleavages. The cleavage of nasonite, however, should be designated as poor, scarcely distinct, while ganomalite is described as having distinct cleavages parallel to the prism *m* (110) and the base. Both minerals exhibit strong positive birefringence. The specific gravity of nasonite, 5·425, is less than that of ganomalite, 5·738, which would be expected, for, although nasonite contains chlorine which is heavier than hydroxyl, ganomalite contains more lead and hence should be heavier. The percentages of lead according to theory are, respectively, nasonite 67·28 and ganomalite 68·98. Thus in their physical properties nasonite and ganomalite are closely analogous, and it may be confidently expected, on the one hand, that if crystals of nasonite are discovered they will be tetragonal, thus conforming to ganomalite, while, on the other hand, ganomalite will be found to contain water in sufficient quantity to yield with the chlorine a ratio of SiO_2: (OH+Cl)=3 : 1. The two minerals furnish an excellent example of the isomorphous relation existing between chlorine and hydroxyl in complex molecules, nasonite being essentially the pure chlorine compound but containing a trace of hydroxyl (water), and ganomalite being essentially the pure hydroxyl compound but containing a trace of chlorine. Both minerals contain a little manganese isomorphous with the calcium.

The acid, $H_6Si_2O_7$, of which nasonite and ganomalite are salts, is intermediate between orthosilicic acid, H_4SiO_4, and metasilicic acid, H_2SiO_3, and it may be regarded either as equivalent to their algebraic sum, or as derived from two molecules of orthosilicic acid by taking away one molecule of water. The latter relation may be expressed as follows:

Two molecules of orthosilicic acid.



Intermediate or mesosilicic acid.



The intermediate acid $H_6Si_2O_7$ is one which has been recognized by mineralogists, but its salts have not generally received a prominent place in the systematic classifications of silicates, because they are not very numerous. Groth* calls attention to the acid and its salts, and has given the name "*Diorthokieselsäure*" to the acid. Clarke† also has discussed the chemical relations of the minerals of this group, adopting Groth's name *diorthosilicic acid*, and calling the minerals *diorthosilicates*. The name *diorthosilicic* seems, however, inappropriate, since $H_6Si_2O_7$ is not an orthosilicic acid as the name signifies, but a derivative of orthosilicic acid. We feel, therefore, warranted in suggesting new names, *mesosilicic* for the acid and *mesosilicates* for its salts, the prefix *meso* being derived from μέσος, signifying middle or between. The intermediate relation of mesosilicic acid is evident from the following:

Orthosilicic acid, two molecules,	$H_8Si_2O_8$.
Mesosilicic acid,	$H_6Si_2O_7$.
Metasilicic acid, two molecules,	$H_4Si_2O_6$.

The mesosilicates are classed by Dana in the small group of "Intermediate Silicates" on page 416 of his Mineralogy, and by Groth as "*Intermediäre Silikate*" on page 138 of his *Uebersicht der Mineralien*.

The commonest mesosilicate is iolite, the composition of which may be expressed as a slightly basic salt, as follows: $(Mg, Fe)_4Al_6(Al.OH)_2(Si_2O_7)_5$, although the two hydroxyls may be in combination with the bivalent metals instead of with the aluminium. One of the few lead silicates, barysilite, $Pb_3Si_2O_7$, is a normal salt of mesosilicic acid, as is also the Franklin mineral hardystonite, $Ca_2ZnSi_2O_7$, recently described by Wolff.‡ Hardystonite is said to occur at the Parker shaft, North Mine Hill, but we have not yet observed it associated with any of the new minerals described in the present paper.

* Tabellarische Uebersicht der Mineralien, IV Auflage, pp. 105 and 140.
† Constitution of the silicates; Bull. of U. S. Geolog. Survey, No. 125, p. 81.
‡ Proceedings of the Am. Acad. of Arts and Sci., xxxiv, p. 479, 1899.

4. Leucophœnicite.

This mineral made up the larger part of a specimen about two inches in length and breadth by one inch in thickness, which was found by Mr. J. J. McGovern of Franklin, and given to C. H. Warren in 1897. It has also been observed in small amount on a few specimens sent to us by Mr. W. M. Foote. The mineral has a crystalline structure, vitreous luster, hardness about 5·5–6, and is conspicuous on account of its light purplish-red or raspberry color. It was supposed at first to be clinohedrite, rather deeply colored by manganese. It is intimately associated with willemite of almost gem-like quality and beautiful light green color, and with small idiomorphic crystals of brown vesuvianite, showing prisms of the first and second order, pyramid of the first order and base. Occasional crystal faces were observed on the leucophœnicite, but none which gave any clue to the system of crystallization.

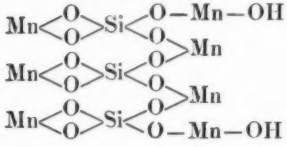
When small fragments of the mineral are imbedded in balsam and examined with the microscope it may be seen that the fragments are mostly irregular, although some are flat and appear to lie upon imperfect cleavage faces. There also may be seen irregular cracks indicating a second but not distinct cleavage. In polarized light the extinction seemed to be slightly inclined to the direction of the second cleavage, and in convergent light an optical axis was observed near the limit of the field. The fragments showed a slight pleochroism, pale rose for vibrations parallel to the direction of cleavage, and colorless at right angles to this direction. These properties indicate that the material probably crystallizes in one of the inclined systems, although wholly satisfactory conclusions could not be drawn.

Very pure material for the chemical analysis was obtained by crushing a portion of the best specimen, and selecting the purest particles by hand. The specific gravity was found to be 3·848. The results of the analysis by Warren are as follows:

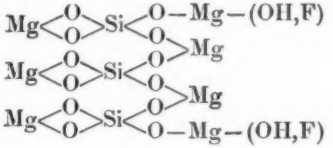
	I.	II.	Average.		Ratio.	
SiO_2	26·31	26·41	26·36	·439		3·03
MnO	60·59	60·67	60·63	·854		
ZnO	4·03	3·72	3·87	·047		
FeO	----	----	trace	----		
MgO	0·21	----	0·21	·005	1·015	7·00
CaO	5·64	5·70	5·67	·101		
Na_2O	0·39	----	0·39	·006		
K_2O	0·24	----	0·24	·002		
H_2O	2·70	2·58	2·64	·146		1·01
			100·01			

Letting R stand for the metals (chiefly manganese) the ratio of $SiO_2 : RO : H_2O$ is $3{\cdot}03 : 7{\cdot}00 : 1{\cdot}01$, or a close approximation to $3 : 7 : 1$, and this leads to the general empirical formula $H_2R_7Si_3O_{14}$. Since water is not expelled from the mineral much below a red heat, the hydrogen must exist in the form of hydroxyl, and, consequently, the foregoing formula may be written $R_5(R.OH)'_2(SiO_4)_3$ or as a basic orthosilicate, exactly equivalent to humite except that no fluorine is present. Considering the base wholly as manganese, the following is suggested as a structural formula of the mineral, which certainly appears simple and reasonable, and for comparison the structural formula of humite is also given.

Leucophœnicite.



Humite.



Leucophœnicite is therefore a manganese humite, but it contains no fluorine isomorphous with the hydroxyl. As humite is a magnesium mineral resulting from metamorphism due to fumerole or pneumatolitic action, so leucophœnicite is a similarly constituted mineral, produced probably by like causes at a locality where manganese was abundant. It is probable that the crystallization of leucophœnicite is analogous to that of the minerals of the humite group, and, since the examination of fragments of leucophœnicite in polarized light indicated one of the inclined systems (page 351), it may be inferred that its crystallization is monoclinic, with $\beta = 90$, analogous to chondrodite and clinohumite, rather than orthorhombic like humite. Furthermore, the discovery of this mineral suggests the possibility of finding a series of manganese compounds, corresponding to prolectite, chondrodite, humite and clinohumite. Attention may also be called to the fact that Jannasch and Locke* have described a variety of humite from Valais, Switzerland, exactly analogous to leucophœnicite in that it contains no fluorine.

Before the blowpipe, leucophœnicite fuses quietly at about 3 to a brownish black globule. In the closed tube it yields a little water. Reacts for manganese with the fluxes. The powdered mineral dissolves very easily in hydrochloric acid, and the solution yields gelatinous silica upon evaporation.

* Zeitschr. für anorganische Chemie, vii, p. 92, 189.

The name leucophœnicite has reference to the color of the mineral, and was derived from λευκόσ = pale or light and φοίνιξ = purple-red.

There are other minerals from the locality, some of them evidently new, which have been partially examined, and it is hoped that a full description of them may be given in a future article.

In closing we desire to express our thanks to those gentlemen, named at the beginning of this article, who have generously supplied us with material for carrying on this investigation, and especially to Mr. W. M. Foote, who spent some weeks collecting at the locality in the summer of 1898 and who has called our attention to a number of interesting specimens and associations.

Laboratory of Mineralogy and Petrography,
Sheffield Scientific School of Yale University, September, 1899.

Art. XLII.— *The Action of Acetylene on the Oxides of Copper;* by F. A. Gooch and DeForest Baldwin.

[Contributions from the Kent Chemical Laboratory of Yale University—LXXXIX.]

In a recent paper by Erdmann and Köthner* an account is given of the formation of a peculiar, light-brown, highly voluminous substance by the action of acetylene below 250° C. upon cuprous oxide, or even (though more slowly) upon copper. The product obtained by passing acetylene during eighteen hours over 1 grm. of cuprous oxide (prepared from copper sulphate, grape sugar, and sodium hydroxide) amounted to 7 grms. and filled a space of nearly 300^{cm^3}. At higher temperatures a black carbonaceous mass is the result, and at red heat (400°–500° C.) carbon is deposited in graphitic condition. The light-brown fluffy material yielded cuprous chloride to hydrochloric acid, a distillate from its mixture with zinc dust possessing the characteristics of naphthene or, at higher temperature and under rapid heating, aromatic compounds among which naphthalene and a kresol were indicated. Erdmann and Köthner classify this body as a very complex but non-explosive copper acetylene (acetylen-kupfer), and from their analyses deduce the formula $C_{44}H_{44}Cu_2$. Apart from the unusual constitution of this symbol, its most striking peculiarity is that it implies a loss of carbon, rather than hydrogen, from the acetylene in the reaction with cuprous oxide—a condition of affairs which would be most remarkable in the light of Campbell's experience,† according to which acetylene passed over palladinized copper oxide yielded water at 225°–230° and carbon dioxide only when the temperature rose to 315°–320° with the formation of a black deposit. Upon scrutinizing the figures of Erdmann and Köthner with care, however, it appears that the formula given by these investigators rests upon some oversight in calculation: the ratio of carbon atoms to hydrogen atoms proves to be actually, according to the data given, 6·45 : 5·70; which means, of course, that the new product is deficient, as would be expected, in hydrogen (not in carbon) as compared with acetylene.

As to the content of the new substance in copper, the analytical data are unfortunately ambiguous: for we note the weights found of *copper oxide* converted into percentages of *copper* without preliminary reduction. If the fault is typographical and in the analytical data, the calculated percentages of copper being correct, the average percentage of copper amounts to 15·43: if, on the other hand, the analytical data

* Zeitschr. für anorg. Chem., xviii, 49. † Amer. Chem. Jour., xvii, 690.

are right, the error being in their reduction, the percentage of copper amounts to 12·92. In the one case the summation of the analysis leaves a deficiency of about 1·5 per cent, and in the other of about 4 per cent, which in either case may really represent oxygen in the substance. This condition of matters leaves the "acetylen-kupfer" of Erdmann and Köthner in uncertain standing.

More than thirty years ago it was noticed by Berthelot* that acetylene is polymerized by heat or decomposed partially into carbon and hydrogen, and that such action takes place more readily and at lower temperatures in presence of metallic iron with production of carbon, hydrogen and compounds different from those formed by heat alone.

Moissan and Moureu† have observed the incandescence of acetylene passed over finely divided iron, cobalt, nickel or platinum at the ordinary temperature, with production of carbon, hydrogen, and pyrogenic compounds, and have found the occasion of such behavior in the porosity of the metals employed.

It would seem natural, however, that the presence of oxygen, free or combined, may also play a considerable part in such phenomena, just as appears to be the case in the peculiar action recorded by Gruner‡ of carbon monoxide upon iron reduced by hydrogen, which, as Moissan has shown,§ is produced pure only with the greatest precaution and generally carries a large proportion of ferrous oxide. The fact that the "acetylen-kupfer" of Erdmann and Köthner is produced more easily by the action of cuprous oxide upon acetylene than by the action of metallic copper upon acetylene, suggests that it may be the oxidizing power of the cuprous oxide which gives to this reagent its peculiar activity. The question arises, therefore, as to whether the copper is in reality an essential constituent of the compound of Erdmann and Köthner.

In our experiments upon the action of acetylene upon the oxides of copper (and other elements) we have conducted the gas (made in the ordinary way by the action of water on calcium carbide, and kept over water) over the oxide contained in a porcelain boat placed within a glass tube, 2^{cm} in diameter and 50^{cm} long, which was heated over a small combustion furnace. The glass tube was fitted at each end with a rubber stopper, one carrying a smaller tube for the introduction of the acetylene and a high-temperature thermometer so held that its bulb rested horizontally immediately over the boat containing the oxide, while the other was fitted with a water-trap. In the

* Ann. d. Chim. et d. Phys. [4], ix, 448. † Compt. Rend., cxxii, 1240.
‡ Ann. d. Chim. et d. Phys. [4], xxvi, 5.
§ Ann. d. Chim. et d. Phys. [5], xxi, 199.

preliminary experiments no attempt was made to purify the acetylene employed other than to keep it over water, or, since water is a product of its action upon oxides, to dry it: in later experiments to secure products for careful analysis it was dried and purified with care.

We found that 225° C. is the temperature most favorable for the formation of the voluminous product obtained by acting with acetylene upon cuprous oxide as described by Erdmann and Köthner. At this temperature the tube is choked rapidly with the fluffy product and water forms, but, as Campbell found in his experiments upon palladinized copper oxide, no appreciable amount of carbon dioxide is produced. The content of the product in copper varies in the sample and in different experiments, our results lying between 1·54 per cent and 24·21 per cent of the substance taken for ignition.

It appeared, also, that the action of acetylene upon cupric oxide is precisely similar to that upon cuprous oxide excepting the evident reduction of the former oxide early in the action. The amount of copper in the product of such action varied in our experiments from 6·53 per cent to 21·30 per cent. In one case the experiment of re-submitting to the action of acetylene a product containing 9·34 per cent of copper was made with the result that a new growth of the substance formed which on analysis yielded 3·87 per cent of copper.

A roll of copper gauze carefully reduced in hydrogen and then oxidized at one end in the outer flame of a Bunsen burner gave, when acted upon by acetylene at 225°–250° C., the characteristic deposit upon the oxidized end only, the unoxidized end being merely discolored.

These results go to show that, while metallic copper may at comparatively high temperatures induce the polymerization of acetylene, it is an oxidizing action which starts at moderately low temperatures the formation of the peculiar derivatives under consideration. Thus we find that ferric oxide heated in acetylene at temperatures varying from 150° to 360°, according to circumstances, darkens, glows, and gathers with evolution of heat a dark carbonaceous deposit. In the products of such action we have found the content of iron varying from 2·80 per cent to 5·86 per cent.

Silver oxide, too, acts upon acetylene: thus, in one experiment, action was evident at the ordinary atmospheric temperature, a violent explosion, which completely shattered the boat and scattered metallic silver upon the sides of the glass tube, following before the temperature reached 100°.

In the locally violent explosion of the last experiment we have evidence of the formation in the early stage of an acetylide which is decomposed later when the temperature of disso-

ciation is reached. In the experiments with the oxides of copper and iron the temperature at which the acetylene begins to act is evidently above the point at which sensitive acetylides would naturally dissociate, and we have in the observed phenomena no evidence of the formation of such compounds of copper and iron under the conditions of experimentation.

In experiments (1) to (3) of the following table are given the results of the analysis of several products obtained by conducting acetylene (purified by passing through a solution of mercuric chloride in hydrochloric acid and dried over caustic potash) over pure cuprous oxide. The temperature was kept in these experiments at 225°, and in the course of a half hour the tube was choked completely by material compacted by the pressure to (1) a spongy mass of light brown color on the exterior next the walls of the tube, (2) darker within and (3) nearly black in the bottom of the boat, where the cuprous oxide lay originally.

In experiments (4) and (5) the substances analyzed represent the products of the action of acetylene (not specially purified) on cupric oxide.

Weight of substance taken. grm.	Found. CO_2 grm.	H_2O grm.	CuO grm.	Calculated. C grm.	H grm.	Cu grm.	O by difference grm.
(1) 0·1170	0·3978	0·0673	0·0022	0·1085	0 0075	0·0018	—0·0008
(2) 0·2247	0·7489	0·0979		0·2042	0·0109		
(3) 0·1096	0·3678	0 0488	0 0045	0·1003	0 0054	0·0036	0·0003
(4) 0 1360	0·4116	0·0579	0·0182	0·1123	0·0064	0·0146	0·0027
(5) 0·1188	0·3098	0 0461	0·0317	0·0845	0·0051	0·0253	0·0039

	(1)	(2)	(3)	(4)	(5)
Per cent of carbon	92·74	90·88	91·51	82·57	71·13
" hydrogen .	6·41	4·85	4·93	4·71	4·29
" copper ...	1·54		3·29	10·74	21·30
" oxygen ...	----		0·27	1·98	3·28
	100·69		100·00	100·00	100·00

The oxygen present in these products is obviously proportional to the amount of copper and is never more than enough to be completely accounted for upon the supposition that some of the original oxide taken still holds its oxygen. So far as the analyses show, the product of lightest color (1) contains very little copper and no oxygen; the darkest product (3) obtained from the cuprous oxide contains oxygen corresponding to a mixture of two parts of copper with three parts of cuprous oxide; the oxygen in the products of (4) and (5)

obtained by acting upon cupric oxide is approximately enough to correspond to a mixture of cuprous and cupric oxides in equal proportions. This fact, taken in connection with the great range of variation in proportion and the minimum to which the copper falls in the product, which would be least likely to include contaminating metal or oxide, suggests very strongly the probability that the oxygen present is in union with copper and that the copper is held mechanically as metal or oxide and is not the essential constituent of an organic compound. Leaving out of consideration, therefore, the copper and copper oxides, and calculating the composition of the products assumed to consist essentially of carbon and hydrogen, we derive the following statement:

	(1)	(2)	(3)	(4)	(5)
Per cent of carbon....	93·54	94·93	94·88	94·60	94·31
Per cent of hydrogen..	6·46	5·07	5·12	5·40	5·69
	100·00	100·00	100·00	100·00	100·00

These figures correspond to symbols varying from $C_{12}H_{10}$ to nearly $C_{16}H_{10}$, with an average approximating $C_{14}H_{10}$, the symbol of anthracene or paranthracene. The analytical data of Erdmann and Köthner point in the average to a product corresponding more nearly to the first of these symbols than to either of the others. The product is doubtless variable with the temperature and the activity of oxidation. Thus, in one experiment in which acetylene was passed over ferric oxide the action began at 365° with incandescence, as described by Moissan and Moureu,* and the analysis of the product (carbon = 91·53, hydrogen = 1·36, Fe = 5·85, O = 1·26) indicates a proportion of carbon to hydrogen about four times as great as that of the average product of action at 225° on the oxides of copper.

Finally, we find no evidence that the product of the action of acetylene on the oxides of copper under the conditions of our experimentation is other than a mixture of a hydrocarbon or hydrocarbons with metallic copper or an oxide of copper, and, probably, in the darker preparations, some free carbon.

* Loc. cit.

Art. XLIII.—*Andesites of the Aroostook Volcanic Area of Maine;** by Herbert E. Gregory.

Andesites are rare rocks in the eastern United States, but are the most abundant extrusives so far found in northern Maine. They form prominent hills and determine the general topography in some places, while in others they are represented by isolated remnants among the sedimentaries. The greater number of occurrences are of lava and breccia, but andesitic ash and tuff are also found well developed. In the following descriptions only the more important localities will be dealt with in detail. The andesites are located in Aroostook County in the townships of Chapman, Mapleton, and Castle Hill, where they constitute prominent ridges, known as Edmund's Hill, Hobart Hill and Castle Hill, and several less noticeable masses.

Field Description.

Edmund's Hill Andesites.—Edmund's Hill is situated in Chapman township near the middle of the north township line, and is simply the highest part of a ridge running N.–S. for several miles. The hill itself rises some 200 feet above the road at its base and presents the outline of a drumlin—so evenly has it been graded at each end. The trees, brush, talus, and glacial deposits entirely conceal the formations about the base of the hill, and it is only after climbing half the distance to the top that the bare rock is found in place. In climbing up the west side of the hill fragments of fossiliferous sandstone were found amongst the andesite blocks, and about 100 feet below the top the sandstone ledge outcrops. The thickness and extent of the sandstone could not be determined accurately because covered in so many places with heavy blocks and small fragments of the igneous rock fallen down from above. The contact was not seen. The entire top of the hill is of augite-andesite. The main mass is uniform in texture and cut by cleavage cracks into large blocks, which, when they fall down the slope, remain as huge masses. The south and north ends, however, and part of the west side are quite different. Here the rock is split up into long, thin slabs by a set of parallel cracks remarkably uniform in direction and length, and they retain their parallelism even when the rock is folded or faulted. Cross cleavages intersect these cracks every few feet,

* A portion of a thesis on the "Geology of the Aroostook volcanic area of Maine" presented for the doctorate degree at Yale University in 1899. The full report will appear later as a publication of the U. S. Geological Survey, to which, under the direction of Prof. H. S. Williams, the author owes the opportunity of making the investigations here recorded.

so that when the rock is loosened it comes out in flat slaty pieces one-quarter inch or so in width and several inches or even feet in area. The whole appearance is that of thin-bedded sedimentaries which have been folded and faulted. The general direction of these cleavage planes is N. 30° E. on north end and N. 35° E. on south end with a dip southeast at a high angle. The fault planes strike N. 70° E. and besides their effect at the ends of the hills in cutting out the thin slabs they occur all along the west side, each indicating a slight movement. It seems probable that the Edmund's Hill ridge owes its origin in part to the formation of a fault block.

The outlying knobs and hills to the east of the main mass are also of andesite, usually microcrystalline, but sometimes porphyritic. The igneous rock does not extend far to the west, but is replaced by arenaceous slates, and while no precise boundaries of the formation were determined, the field relations suggest that the hill is the remnant of a lava flow over the eroded and upturned edges of sandy rocks of Silurian age.*

Andesites of Hobart Hill.—This hill is an isolated mass of andesite forming a prominent feature in the landscape as one looks west from Presque Isle village. It is situated partly in Mapleton and partly in Chapman townships, and is surrounded entirely by low, poorly-drained swamps and forest lands, and visited only for lumber and tan-bark, which are secured in limited quantities during the winter season. The hill is about $1\frac{1}{4}$ miles long and $\frac{3}{4}$ miles wide, and rises quite abruptly above the plain to a height of 300 feet as a single well defined mass without branches or outlyers. The sides are everywhere quite steep, and in places present cliffs forty to fifty feet high. The top is bare only where fire has recently destroyed the vegetation. The talus slopes present a confused mass of large and small blocks of andesite which entirely conceal all outcrops except where cliffs are exposed. On the west and north sides numerous bowlders of red sandstone and conglomerate are piled along the slope and mingled with the volcanic material. These were traced to their parent ledges scarcely a half mile to the north, and the bowlders serve to cover the contact of the andesite with the Mapleton sandstone.† Specimens collected from various places on the hill show but slight differences in composition and texture except the rock from the northwest corner, which is a breccia of andesitic fragments and

* The sandstone at Edmund's Hill contains an Eodevonian fauna which corresponds closely with that of the Gaspé sandstone. I have given it the name Chapman sandstone.—H. S. Williams.

† The "Mapleton sandstone" here referred to is a massive, and in places coarse, red sandstone, in which plants (Psilophyton, etc.) have been found. It is of Devonian age but somewhat younger than the Chapman sandstone—H. S. W.

seems to be situated along a fault line. As was the case with Edmund's Hill, so here, no actual contact between formations was observed, but the sedimentaries were traced to the very base of the hill, and the facts indicate that the hill is a remnant of a lava flow.

Andesites of South Mapleton.—In addition to the prominent hills of andesite just mentioned, there are some ten or twelve less conspicuous outcrops in the southern part of Mapleton township crossed by the Mapleton–Presque Isle road and located in the fields to the north and the south of this road. They occur usually as narrow ridges, and seem to be remnants of lava flows which occupied former valleys, but are now left standing because of the erosion of the sedimentaries on both sides.

Andesites of Castle Hill.—Castle Hill is the local name for the northern end of the high, narrow ridge extending N.–S. across the township with the same name. While not such a conspicuous feature as Haystack Mountain at the southern end of the same ridge, it forms the most considerable prominence on the immediate bank of the Aroostook River along which route all the early travel lay, and hence was an important landmark to the first settlers. There is no common local usage as to the limits of Castle Hill, and in this report the term will be applied to the masses of andesite and volcanic clastics which lie between the Aroostook River and the "State Road" from Ashland to Presque Isle. It covers an area $2\frac{1}{2}$ miles long varying in width from $\frac{1}{2}$ to $\frac{3}{4}$ mile, and is partly in Castle Hill township and partly in Wade plantation. The wagon road crosses the hill at its southern end, where it rises little higher than the surrounding plain. The eastern side has a gentle slope, and is cut up into several low knobs by small streams, so that the ridge effect is not apparent. The west side is formed by Welt's brook and the Aroostook River, which at this point is forced by it to take the abrupt backward turn so noticeable on the map. Calcareous and arenaceous slates are exposed in the bed of the river, while a short distance back steep slopes and cliffs of lava and ash rise to a height of several hundred feet. The hill is densely wooded and in places swampy except at the southern end and along the east side. At these points the bare rocks are occasionally exposed and present a great variation in character. In one place heavy ledges of gray andesite are exposed, particularly on the knobs occupying the northwest and southeast corners of lot 31. Again in the woods east of the mouth of Welt's brook is an outcrop of black silicified tuff between slates. On the southeast corner of the hill are loose ash beds containing fossils, coarse and fine volcanic breccias, and pumiceous lava in quite fresh condition. Where

the glaciers have planed off the old lavas and they have been protected from weathering, the outlines of bombs and pillows are plainly revealed, and when weathered these bombs are loosened and drop out as oval or egg-shaped bodies with amygdaloidal surface and denser interior, and lie about thickly strewing the fields. In one place there is a cistern-like depression some ten feet deep and thirty feet in diameter made in the solid andesite, while about it are piled close at hand a great number of very vesicular bombs and much glassy and brecciated ash. The whole appearance suggests a small blowhole made by a single explosion. The striking fact about all the volcanic accumulations in the Castle Hill region is their freshness and their unmistakable character.

Petrography.

Generally speaking, the andesites of this region belong to well-recognized varieties widely distributed over the earth and differ in no important particulars from the type rocks of their class. There are varieties found here, however, which are intermediate between andesites and trachytes and also occurrences with dacite facies. The exposures are numerous and easy of access and the specimens are no more altered in composition than if they were Tertiary lavas instead of Paleozoic.

Augite-Andesite—Macroscopic description.—The largest and best single exposure of andesite in this region is of this variety and forms the main mass of Edmund's Hill. It does not occur as a solid compact mass, but is broken by cleavage and shearing planes into large blocks on top, and into plates and slated material at the ends of the hill. This slated and seemingly bedded appearance, which is so unusual in an igneous rock, is the most marked peculiarity of the structure of the hill. In a few places the rock is seen to contain embedded angular pebbles of glass and baked siliceous material which stand out when it weathers; and in other places the rock presents a banded surface of gray and brown giving the appearance of bedding, but which prove on examination to be varying stages of decomposition along potential cleavages. With these exceptions the exposed rock has a uniform appearance, gray where weathered, black where fresh.

Andesites are so well known that an extended macroscopic description is unnecessary and will not be attempted. The hand specimen appears as a black, basaltic-looking rock, generally dense, with a stringy effect and sprinkled over with glassy feldspar 2^{mm} and less in length. The weathered surface is a layer of spongy, gray-brown material in which the pores are made by the decay of the larger feldspars. At the east end of

the hill the rock is much lighter in color and numerous white feldspars give it a more porphyritic appearance.

Microscopic.—As with the hand specimen, so microscopic examination reveals the composition and structure expected of a typical andesite. Magnetite, apatite, pyroxene, plagioclase, and orthoclase are the original minerals present. The plagioclase crystals range in size from laths 2^{mm} in length down to the very fine ones in the groundmass, but the larger ones are not abundant and do not give the rock a porphyritic aspect. The plagioclase forming the crystals outside the groundmass was determined by Michel Lévy's method to be labradorite; but the measurements indicated two labradorites with the formulæ: Ab_3An_4 and Ab_5An_6. The larger feldspars show strongly marked zonal banding with occasionally as many as eight distinct zones, which decrease in basicity from the center outward, but with the original albite twinning running through the whole series. This albite twinning shows in nearly every feldspar lath with great distinctness, and twins on the pericline and manebach laws also occur. The carlsbad twins present are often with one-half dropped much below the other, and all the twinning is more or less along irregular ragged lines and with unsymmetrical development. None of the feldspars are entirely fresh, but are kaolinized along the cleavages and zonal boundaries, or entirely altered to kaolin and calcite except their outer borders. They also show irregular cracks other than cleavage along which strain has been relieved. Glass inclusions, arranged without order, are numerous and stand out prominently in the clearer parts of the feldspars. Orthoclase was not found outside the groundmass except as forming the wide outer rim of the zonally-built plagioclases.

The Pyroxenes are of both monoclinic and orthorhombic varieties. The monoclinic is an augite, light colored in thin section and having an average extinction on prism sections of 42°. The basal sections are quite fresh and show the cleavage parallel to the prism. The pinacoids are more developed than the prism faces and give the appearance of a square with truncated corners rather than the more common octagonal effect. The prism sections vary from stout forms to those five or six times as long as broad. In places many small pieces are arranged in parallel position and separated by alteration products in such a way as to suggest the presence of augite phenocrysts of which these fragments are the remnants. The orthorhombic pyroxenes are represented in the darkest colored rocks by a few basal and prism sections, but in the gray varieties it constitutes fully half of the pyroxenes present. It is very light colored, not at all pleochroic, and is at times partly eaten away and again occurs as parallel intergrowths with the

augite. It seems to be a variety poor in iron, is optically +, and hence referred to enstatite. In the fresher rock specimens the cleavage cracks and borders of the enstatite often show the presence of a red-brown fibrous mineral. In the more weathered rocks this mineral assumes a prominent role. It is here found intergrown with augite and forming fibrous laths with parallel extinction. Its pleochroism is distinct with a = light brown, c = light green. The presence of this mineral in a slide seems to be in proportion to the absence of the orthorhombic pyroxene, and this fact together with its shape and optical properties point to bastite and make the supposition plausible that the red-brown mineral is the present representative of the original orthorhombic pyroxene. The magnetite is present in grains or dust aggregates, and the apatite occurs in needles, laths, and rounded sections within the feldspars.

The *groundmass* consists essentially of feldspar laths, long, narrow, with ragged outline and split ends, arranged with trachytic structure tending toward the hyalopilitic, and with flow phenomena developed in places. No close distinction can be drawn between the groundmass feldspars and those which rise slightly above it, as all sizes are represented grading up to the very largest ones present. Optical measurements on some of the freshest pieces in the groundmass proved them also to be labradorite, although orthoclase must also be present as demanded by the analysis. Besides the feldspars, augite grains are scattered abundantly throughout and small areas of brown glass, occasionally with bubbles, also occur. The whole slide is darkened by iron dust, both magnetite and limonite or göthite. The rock is, however, in a remarkably fresh state considering its age and position, and its character is unmistakable.

Analysis.—The analysis of this rock made by Dr. W. F. Hillebrand of the U. S. Geol. Survey is given in column I below and with it analyses (columns II–VI) of well known andesites from other localities are given for comparison.

From a study of the tables it becomes apparent that the Edmund's Hill rock presents no points of distinction from recognized types found elsewhere, and the tables could be greatly enlarged by the addition of closely similar analyses. The analysis in column VII requires some notice. The rock is described as a red andesite with "rather basic" feldspars and with calcite and magnetite present. The altered condition of the rock made accurate optical determination impossible. In discussing the analysis the writer says (l. c. p. 34), "In its mineralogical composition, this rock approaches the basaltic type but, as the analysis shows, is somewhat too acid. The olivine phenocrysts, moreover, are not very numerous and there

	I	II	III	IV	V	VI	VII
SiO_2	61·40	61·58	61·29	61·04	61·45	61·17	63·25
Al_2O_3	16·59	16·96	17·68	15·72	15·07	17·74	14·89
Fe_2O_3	2·13	1·75	6·03	5·03	4·46	1·78	6·54
FeO	3·05	2·85	·30	2·15	1·18	3·51	none
MgO	2·73	3·67	2·45	3·61	3·02	2·76	·82
CaO	6·17	6·28	5·61	5·34	5·37	5·90	·59
Na_2O	3·83	3·94	4·28	4·02	4·00	3·79	4·47
K_2O	1·34	1·28	1·38	2·66	1·22	1·71	4·78
$H_2O-105°$	·82	·24	·96	·58	1·23	·83	2 67
$H_2O+105°$	·88	1·06					
TiO_2	·79	·49	·65			·45	trace
ZrO_2	none						
Cr_2O_3	trace					none	
V_2O_3	·02						
NiO	trace						
MnO	·13	trace			none	·12	
BaO	·02	·03				·06	
SrO	trace?	trace				·04	
Li_2O	trace	trace			·05	trace	
P_2O_5	·20	·22			trace	·14	·61
CO_2	none						·78
Cl	?						
Fl	?						
FeS_2	none				(SO 3 ·29)		loss ·53
	100·10	99·23	100·63	100·15	100·14	100·00	99·93

I. Andesite, Edmund's Hill, Aroostook Co., Maine. Analysis by W. F. Hillebrand.

II. Hornblende andesite, Mt. Shasta, Cal. Analysis by N. H. Stokes, Bul. U. S. Geol. Survey, 148, p. 190.

III. Hornblende dacite, Anzeion, Ægina. Analysis Dr. A. Röhrig, H. S. Washington, Jour. of Geol., vol. iii, p. 150.

IV. Pyroxene andesite, Peñon de Pitayo, United States of Columbia. Kuch: Geol. Studien in der Republik Colombia, Pt. I. Berlin, 1892.

V. Pyroxene andesite, Agate Creek, Yellowstone National Park. Analysis by Whitfield, U. S. Geol. Survey, Bul. 148, p. 134.

VI. Hypersthene andesite, Crater Peak (Lassen Peak Region). Analysis by W. F. Hillebrand. U. S. Geol. Survey, Bul. 148, p. 197.

VII. ? Andesite, Fox Islands, Maine. Analyses by E. W. Magruder and W. A. Jones in Johns Hopkins University Laboratory. G. O. Smith, Geol. of Fox Islands, Maine. Presented as a thesis, Johns Hopkins University, 1896.

is reason to regard this as simply an olivine-bearing phase of the andesite." The description is of an andesite, but there are discrepancies between the description and the analysis. No ferrous iron is present to form magnetite, and if the small amount of lime forms calcite, basic feldspars could not be produced. And even if the whole 0·59 per cent of lime were present as andesine or labradorite the amount is far too small for an andesite. According to the generally accepted usage among petrographers, a rock with such a high percentage of soda and potash with little lime and magnesia would be classed as a trachyte or more closely, an ægerine-trachyte.

Hornblende-andesite.—The largest single mass of this rock is Hobart's Hill, and the freshest and most typical specimens are from this hill and from the west bank of the Presque Isle near the northwest foot of the hill, where quarrying was attempted at one time. The hand specimen shows a very dark gray, almost black, rock, fine-grained, but with a somewhat porphyritic appearance caused by the occasional feldspar crystals which rise above the general groundmass and reflect light well from their glassy cleavage faces. Some few feldspar laths attain a length of 5–6^{mm}. The rock breaks out into tabular blocks along the cleavages and weathers to a brownish gray color.

Microscopic description.—In thin section the microscope reveals magnetite, apatite, titanite, rarely a zircon lath, possibly augite, hornblende, plagioclase, and orthoclase together with considerable secondary calcite. The feldspars range from 2^{mm} in length down to minute microlites. The larger feldspars are commonly converted to calcite, which while it indicates their basic character, also prevents their accurate determination. Those which could be measured by the Michel-Lévy method proved to be andesine with formula Ab_1An_1, hence more acid than the feldspars of the augite andesine. They contain glass inclusions, are zonally built with an occasional unaltered outer border, and are twinned according to the Carlsbad and albite laws but with very irregular intergrowths of the parts.

Hornblende is the only important ferro-magnesian mineral present and occurs, as the feldspars, both as large basal sections and long laths often with good crystal outline and also as shreds in the groundmass. The larger pieces are rarely in a good state of preservation, but occur with ragged edges and show resorption phenomena. The crystal is eaten into and part of the interior converted into magnetite with a few augite grains. Some crystals have been almost entirely replaced by calcite and magnetite, and others are represented by a ghost-like outline of magnetite dust. Commonly the hornblende is now changed to a green micaceous material, perhaps a variety

of chlorite, with parallel extinction and a pleochroism, c = white green, a = brown green. At times the former crystal is striped across with alternating bands of green and white in the direction of the cleavage cracks. Some of the crystals classed as hornblende are so altered that it is impossible to say that they may not be augite.

The groundmass is formed of small, stringy, ragged feldspars and varies in different slides from trachytic or pilotaxitic, with possibly a little glass, to a type formerly quite glassy and showing devitrified areas with incipient micropoikilitic structure. The feldspar microlites could not be accurately determined, but their average extinction indicates a variety as acid as oligoclase-andesine, and if strict nomenclature were to be considered, the rock would be classed as a trachyte-andesite.

Andesites of Southern Mapleton.—These occur in several localities and are either identical with, or present only minor variations from, the Edmund's Hill and Hobart's Hill masses. The rock which outcrops in the road two miles east of Mapleton village has the most glassy groundmass of all the andesites, and its devitrified areas have the micropoikilitic structure the best developed. Two outcrops show a type much lighter in color with much secondary and some original quartz, giving the rock a dacite facies. The other sections examined are of the typical augite-andesite or hornblende-andesite of this region, and require no detailed description.

Andesites of Castle Hill—Macroscopic description.—The rocks at this place do not have the character of lavas which have formed thick flows, but suggest rather the surface of a flow and are commonly amygdaloidal, or even slightly brecciated and ashy, and associated with them is an abundance of true volcanic ash with lapilli. The rock exposed at the southeast base of the hill is striking in its field appearance. Black, rusty-looking, spheroidal or elliptical masses of lava, one to two feet in diameter, first attract the attention as they lie loosely strewn over the surface. The solid ledge itself is seen to be composed of these forms, which have their outlines well displayed by weathering. These sack-like or pillow-shaped masses are plainly amygdaloidal on the surface, but usually much denser in the interior and are cemented together by a coarse breccia of rough tabular, spheroidal, or irregular jagged fragments of glassy material and igneous rock of similar composition to the spheres. In some places, noticeably on McDonald's hill to the south of Castle Hill proper, this structure assumes the form of a conglomerate of small amygdaloidal spheres six inches and less in diameter, closely cemented together with angular pebbles of andesite and other igneous

rocks. Similar structures have been described from California,* and from Scotland† and elsewhere. As noticed by Geikie, some basic lavas, e. g., the basalt at Acicastello in Sicily,‡ on flowing into water or a watery silt, assumes a remarkable spheroidal or pillow-shaped structure, "the spheroids being sometimes pressed into shapes like piles of sacks." This may be the explanation in the present case. Another interpretation is that the structure represents the ropy rolling surface at the front of a lava flow. On a fresh surface the rock is dark bluish-gray, uniform in texture or with a rare feldspar phenocryst. While this appears to be the most typical of the textures, it is usual to find vesicles now filled with calcite and fragments of volcanic debris large enough to constitute a conspicuous feature in the hand specimen. In weathering, the amygdaloidal parts go first and leave the more dense igneous and glassy pebbles exposed as a very rough surface.

Microscopic description.—Sections were cut from the densest material and also from that with macroscopic inclusions, and when examined with the microscope showed no difference except in size of vesicular areas and in method of alteration. Feldspar microlites make up the rock, parts of which are developed as areas of vesicular lava. The vesicles range in diameter from 2^{mm} to microscopic dots and are rudely oval in outline. The large ones are merely the larger part of a rounded area of vesicular glassy lava, containing a few feldspar threads like the body of the rock. Sometimes instead of one vesicle, filled with calcite, the same space will be occupied by a group of them, or the concave inner border of the large one may indicate its formation from several smaller ones. Some glassy oval areas occur with vesicles visible only under the highest powers. All these variations are doubtless caused by the fact that different sections of similar vesicular areas are exposed in the preparation of the slide. The only feldspar phenocryst seen in the sections is rounded in outline, has albite and pericline twinning, and is badly altered to calcite. Its extinction-angle indicates albite or andesine, and from the fact that phenocrysts are usually more basic than the components of the groundmass is referred to andesine. No ferro-magnesian mineral is present, but the numerous patches of chlorite and the fact that augite occurs in similar rock in the immediate neighborhood points to the former presence of pyroxene. Besides chlorite, there are present as secondary products calcite, a few epidote grains, and abundant iron ore. One slide is sprinkled full of stringy

* Ransome: Bull. Depart. Geol. Univ. of California, vol. i, p. 106. Fairbanks: Bull. Depart. Geol. Univ. Cal., vol. ii, p 40.

† Geikie: Ancient Volcanoes of Gt. Britain, vol. i, p 193.

‡ Johnston-Lavis: South Italian Volcanoes, p. 41.

black iron ore in long threads or lines of partly connected dots which are arranged to form barbed arrows or network of fibers which cross at angles of 60° and 90°, thus imitating the sagenite structure of rutile.

The groundmass is of long, stringy, narrow, frayed out microlites of feldspar with trachytic structure. Measurements of many laths gave practically a parallel extinction, thus indicating oligoclase. Expansion structure is developed where the vesicular areas are large enough to affect the orientation of the minute laths constituting the main body of the rock.

Andesite Ash Beds.—Beds of volcanic ash of an andesite character are represented in the region covered by this report. They are particularly abundant about Castle Hill and will be discussed in another place.

ART. XLIV.—*On a new mode of occurrence of Ruby in North Carolina;** by J. W. JUDD and W. E. HIDDEN. With Crystallographic Notes by J. H. PRATT.

PARTS of the State of North Carolina, with adjoining areas in South Carolina and Georgia, have long been known to mineralogists and geologists as among the most interesting of corundum localities; and the researches of the late Dr. Genth, Col. Joseph Willcox, Mr. J. Volney Lewis and many other authors have done much to make clear the mode of occurrence and associations of corundum in this area and in the great corundiferous belt stretching along the line of the Appalachian crystalline area from Alabama in the south to Maine in the north. Quite recently Dr. J. H. Pratt has published a very interesting and admirable discussion of "The origin of the Corundum associated with the Peridotites of North Carolina."†

But of the existence in any part of this area, or indeed in any part of the continent of America, of the red transparent variety of the mineral, to which the term Ruby is properly restricted, there appears to have been no knowledge till about 15 years ago (1884). Nor has there been, as yet, any notice published of the discovery in any scientific journal or magazine, unless we except the brief mention made in the Annual Statistical volume entitled Mineral Resources of the United States, published under the auspices of the U. S. Geological Survey.‡

Some few additional notes upon this interesting occurrence have been published, including press notices, but nothing of a strictly scientific character. We may state that one of us has during the past five years frequently visited the scene of this discovery, and that from time to time we have conjointly examined many of the cut specimens and natural crystals of the rubies from the Cowee district of North Carolina, and that in our opinion their beauty and color appear to be in no way inferior to those from the Mogok district of Burma.

As the material in which these rubies were found appeared so strikingly similar to the alluvium and gravel in which the Burma rubies are obtained, it at one time seemed highly probable that when the thick masses of superficial and detrital material could be sunk through, the rock in which the rubies would be found *in situ* would prove to be a limestone like

* From advance sheets of the Mineralogical Magazine and Journal of the Mineralogical Society, vol. xii, No. 56 (October, 1899).

† This Journal, IV, vol. vi, 1898, p. 49.

‡ 15th Annual Report, 1893–94, U. S. Geol. Survey, volume on Mineral Resources of the United States, Washington, 1894, p. 693; ibid., 16th Annual Report, part iv, p. 599; ibid., 17th Annual Report, part iii, p. 905.

that of Burma. This expectation was strengthened by the finding in the gravels of corundum crystals of similar form, with almost precisely the same association of minerals as occurs in Burma.

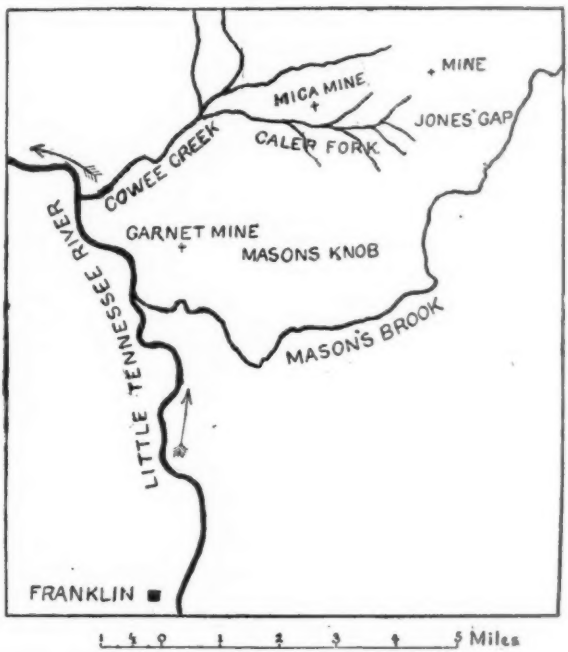


Fig. 1. Sketch map of the district in which Ruby and Rhodolite are found.

The district in which these interesting discoveries have been made is situated in the State of North Carolina and in the County of Macon, rather more than 20 miles from the borders of Georgia. Some five or six miles below the town of Franklin the Little Tennessee River receives on its right or eastern side two affluents, the Cowee Creek with its tributary the Caler Fork, and the Mason Branch. It is the tract between these two brooks, some 10 square miles in area, which has proved to be of such exceptional mineralogical interest, and has yielded a very large number of remarkable species and varieties of minerals.

The bottoms of the valleys of this mountain district are about 2,500 feet above the sea-level, and the various hills

("knobs") in and immediately around it rise to the height of from 3,000 to 3,500 feet; but at no great distance to the west there occurs much higher ground (the Nantahaleh Mountains) up to 5,000 and 5,500 feet.

In 1896 the district was visited and examined by Mr. C. Barrington Brown, who had made the examination for the British Government of the well-known ruby district of Mogok in Burma. He found that the country was one of gneissose rocks, the gneiss often containing garnets and corundum,* not of gem quality, and that this mass of gneissose rocks is probably traversed, like that of Burma, by great dikes of pegmatite and more basic rocks, for blocks of these materials are abundantly scattered through the gravels of the district.

Garnets are so abundant in some of the rocks of the district that mines have been opened to work the rocks for abrasive materials. In some of the pegmatites the crystals of muscovite are so well developed that several "mica mines" have been opened. There are other mines which have been worked for copper with some prospects of success; while, as we shall see in the sequel, gold, monazite, and sperrylite (the rare arsenide of platinum) have been obtained in the alluvial deposits which are so extensively present in this region.

Although only a few miles away from Corundum Hill, Buck Creek, Ellijay, and other famous corundum localities, where, as shown by Lewis, Pratt, and other authors, corundum is found in the intrusive dunites, near their junction with the crystalline schists of the district, *no* olivine rocks, or serpentines derived from them, have been found in the immediate neighborhood of the new ruby locality.

Neither have limestone rocks been found in close proximity to the alluvia containing these fine rubies. In fact, the nearest point at which any limestone bands have been found is about eight miles away. Here the bands consist of a "calciphyre," not unlike some of those found in Burma, and, like them, containing many silicates, such as wollastonite, scapolite, pyroxenes, hornblendes, biotite, etc., with graphite, pyrrhotite, and many other minerals.

When the alluvium and the gravels below them (the latter being from 2 to 10 feet in thickness) are penetrated, they are often found to rest on a soft rock known to American petrologists as "saprolite," which is the result of the weathering in place of basic silicate rocks. This "saprolitic" rock can often be pierced to considerable depths, without the undecomposed rocks from which it has been derived being reached.

* The corundum in these gneissose rocks usually occurs in long hexagonal prisms with basal planes, but no other forms, and the mineral nearly always exhibits purplish tints.

Washing and microscopic examination of the saprolitic material shows that it is largely made up of scales of various hydrous silicates, among which damourite and other hydrous micas, with margarites and other clintonites, are very conspicuous. The unaltered minerals present consist of fibrolite, staurolite, and some other silicates, with menaccanite, rutile, monazite, spinel, and considerable quantities of garnet (including the rhodolite variety) and corundum (of various shapes and tints), and minute quantities of gold and sperrylite.

The trial shafts and gravel-washing operations which have been undertaken in this district, with a view to discover the extent and nature of the valuable minerals, have shown that at depths of 35 feet and upwards the saprolitic rock includes fragments, and is seen to pass into various basic rocks. These include hornblende-eclogite (garnet-amphibolite of some authors), amphibolite, and a basic hornblendic gneiss containing labradorite and perhaps anorthite. The full description of these rocks is deferred until the exploration now going on shall have more fully displayed their relations in the field, and have enabled more satisfactory and less altered specimens to be obtained. It is as yet uncertain whether these rocks occur as dikes or as alternating interfoliated masses in the crystalline series.

The great band of basic and garnet-bearing rocks, in the decomposed materials derived from which are found the rubies, is traversed by a remarkable series of slickensides. Four parallel slides have been exposed at one place in the workings, the direction being generally N. 75° E. Continuous slickensides of 70 feet in length, and of unknown depth, can be seen, and, with some interruptions, they can be traced for several hundreds of feet east and west. It is probably the breaking up of these rock-masses by faulting, leading to the ready influx of water (which so readily attacks the basic silicates of which the rock is composed), that has led to their reduction to the saprolitic condition.

Scattered through the saprolitic material are nuclei of eclogite and amphibolite, which have to some extent escaped disintegration, and in the center of the mass lenticles of pure hornblende rock are found. In one place one of these lenticles of hornblende rock is nearly a rod in width, and in nearly all cases the saprolite adjoining these lenticles of hornblende rock is seen to contain, very abundantly, either corundum or more commonly the pseudomorphs after corundum.

The corundum occurring in these rocks varies in color from ruby-red through various shades of pink to white and nearly colorless varieties. Many of the red crystals exhibit the beautiful so-called pigeon's-blood tint, which is so much admired in

the gems from Burma, and the colors seen in the Cowee Creek stones with the dichroscope are almost identical with those exhibited by the stones from Burma. As at Mogok, Sagyin, and other Burmese localities, the rubies of very fine tint are mingled with others of lighter or darker shades, and with varieties which exhibit more or less of a purplish tint mingled with the red.

The Cowee Creek rubies very frequently contain inclusions of various kinds. Sometimes these are extremely minute ("silk" of jewellers), and give rise to a cloudiness ("sheen") in the polished gems; at other times minute reniform masses of clear red rutile and black menaccanite occur, and mar their beauty. The included crystals of garnet, to be hereafter more particularly noticed, do not greatly destroy the transparency or impair the fine character of the stones. Some specimens have been found, however, from which gems of fair size could be cut, quite free from inclusions and of fine color and transparency.

The clearest crystals of the Cowee Creek rubies nearly always show the tabular habit which Lagorio regards as characteristic of the varieties of corundum that have separated from an igneous magma. Indeed, so common is this form, that any long prismatic crystals found with them may be suspected of having been derived from the surrounding gneisses, in which such forms occur sometimes abundantly. The most common combination of forms is that shown in the accompanying drawing, which has been made by Professor S. L. Penfield, of the Sheffield Scientific School, Yale University.

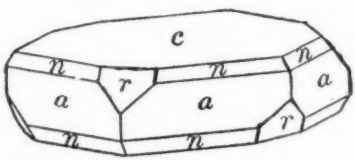


Fig. 2. Common form of Corundum Crystals at Cowee Creek.

In an appendix to this paper Dr. Pratt has drawn and described some of the chief types of corundum crystals obtained in the Cowee district, and it will be found interesting to compare these with the combinations of forms which the same author has described as occurring at Yogo Gulch, Montana,* and which Dr. Max Bauer has described from Burma.†

* This Journal, IV, vol. iv, 1897, pp. 424–428.
† Neues Jahrb. für Min., etc., 1896, Bd. II. pp. 197–238.

The corundum crystals, whether ruby-red or pink in color, occur in "nests" and "bands," and also in what appear to have once been empty spaces in the rocks, either amphibolite, or eclogite, or hornblendic gneiss. The spaces, when the corundum is pale-colored, appear to have been filled up with felspathic material; but when the corundum is of ruby-red color, the surrounding space is filled up with chloritic material.

Corundum is not, however, confined wholly to these bands, which were once druse-like cavities in the rock, but it often happens that the mineral, sometimes red and transparent, is found in the midst of the rock.

One respect in which the corundum of Cowee Creek resembles that of Burma is in the readiness with which it seems to have undergone pseudomorphous change by hydration followed by combination of the resulting diaspore with surrounding silicates. The pseudomorphous material often retains the shape and occupies the place where crystals of corundum were originally firmly embedded in the hard matrix. Often only a thin flake of corundum remains in the midst of a mass of alteration products to tell the character and color of what was once a large crystal.

It is surprising to see the positive evidence of the former existence of hundreds of pounds weight of ruby and other varieties of corundum, where, to-day, only a few ounces of fragments or flakes remain.

The most notable of the minerals associated with the rubies and other forms of corundum at Cowee Creek is garnet, and this garnet is remarkable for its color and beauty as a gem-stone. The color is unlike that either of pyrope or almandine, and lacks that depth and intensity which usually makes garnets such dark-looking stones, especially by artificial light. These garnets, on the contrary, have a peculiar and very beautiful tint, combined with a transparency and brilliancy which is more striking in artificial light than in ordinary daylight. From the resemblance of its color (a pale rosy tint inclining to purple) to that of certain roses and rhododendrons, this variety of garnet has received the name of "rhodolite."*

The rhodolite usually occurs in water-worn fragments, mixed with corundum and the other minerals found in the "saprolitic" rock and in the gravels of the district. Only minute crystals, occurring as inclusions, have as yet been found, and these are sometimes rhombic-dodecahedrons and at other times trapezohedrons (icositetrahedrons). The garnets show the same tendency to alteration as the corundum, and pseudomorphs of the mineral abound, as is the case in Burma.

* The rhodolite of the Cowee Creek and Mason's Branch district has been recently carefully studied by Dr. Pratt in conjunction with one of us.

The association of rubies and rhodolite in this district is not only proved by their constant occurrence together in the saprolitic material and in the gravels, but we found indisputable evidence that the garnets have crystallized first and that the corundum has solidified afterwards and has enclosed the garnets partially or entirely in its crystals. Some of the ruby crystals bear impressions, of which a mould can be taken in wax, and these impressions give with a goniometer the angles of the rhombic-dodecahedron or the trapezohedron. In some cases clear crystals of ruby corundum have been broken open, and minute garnets actually taken out of the middle of them. In other cases fractured surfaces of the basic rocks show corundum surrounding and enclosing garnet crystals, while in other cases cut gems of ruby can be seen to have in their midst a garnet crystal.

So far as our experience goes, this enclosure of garnet by corundum is peculiar to this special Cowee district, and serves to distinguish the corundum found in it from that occurring in any of the tracts where the mineral occurs in peridotites (dunite, etc.), or at the junction of peridotites with the crystalline schists.

This remarkable association of garnet and corundum is well illustrated by a drawing (fig. 3) made upon the spot by one of us from a specimen.

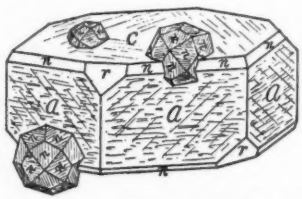


FIG. 3. Corundum enclosing Crystals of Garnet.

Specimens are occasionally found in the district which appear to be pseudomorphs of quartz after dodecahedral garnets.

Spinel, which is so constantly associated with the corundum (ruby) of Burma, is rare in the American locality. The fine red spinels, so similar in tint to the rubies themselves, and so conspicuous in the Burma localities, appear to be entirely wanting in the North Carolina area. Three varieties of spinel, namely, picotite, gahnite, and chromite (the last being rare), have been found both in the alluvial deposits and *in situ* in the basic rocks.

Of minerals specially characteristic of materials formed by contact metamorphism, the following have been found: Sillimanite (fibrolite), cyanite, staurolite (often very clear and gem-like in character), and cordierite or iolite (colorless and without dichroism).

The chief ferro-magnesian silicates are hornblende (a variety rich in soda) and bronzite (in clear transparent masses suitable for gems).

Among the accompanying minerals are: zircon (with the variety cyrtolite), monazite (the macroscopic brown and green varieties appear to be rare, but a minute brilliant yellow granular variety with only 0·03 per cent of thoria abounds), rutile and menaccanite.

Among metallic minerals the chief are pyrite, chalcopyrite, nickeliferous pyrrhotite, blende, sperrylite, and gold.*

Conclusions.

Corundum has now been shown to occur in North Carolina and the adjoining States in three different forms:

(1) In the ordinary crystalline schists of the district, long prismatic crystals, usually of gray, pink and blue tints, occur.

(2) In the peridotites (dunites, etc.), intrusive in the crystalline schists, and especially in and near the zones of contact, crystals, some of very great size and of great variety of color, but seldom or never clear and translucent, are found.

(3) In certain garnet-bearing basic rocks at Cowee Creek, small tabular and short prismatic crystals are abundant, and these very frequently exhibit the transparency and color of the true ruby.

Dr. Pratt, in his recent discussion on the second of these modes of occurrence of corundum, has shown grounds for concluding that the alumina of the corundum was in these cases originally dissolved in the fused basic magma of the peridotites, and that crystals of corundum separated from that magma in the manner which has been illustrated by the interesting experiments of Morozewicz.†

The tabular form of the crystals of corundum has been shown by Lagorio‡ in his well-known memoir on the subject to be characteristic of corundum found in igneous rocks. And this conclusion has been supported by the researches of Prof. L. V. Pirsson and Dr. Pratt.§

If we compare the forms figured by Dr. Pratt in the appendix to this paper with those described by him from Yogo Gulch, the resemblance will be seen to be very striking. But

* For fuller details concerning these accompanying minerals with analyses consult a paper "On the Associated Minerals of Rhodolite," by W. E. Hidden and J. H. Pratt, this Journal, IV, vol. vi, 1898, pp. 463–468.

† Zeitschr. Kryst., vol. xxiv, 1895, p 281, and Tscherm. Min. und Petr. Mitt. vol. xviii, 1898, pp. 1–90, 105–240.

‡ Zeitschr. Kryst., vol. xxiv, 1895, p. 285.

§ "Corundum-bearing Rock from Yogo Gulch, Montana," by L. V. Pirsson, this Journal, IV, vol. iv, 1897, p. 421; "Crystallography of the Montana Sapphires," by J. H. Pratt, ibid., p. 424.

it may at first sight appear that it is impossible to ascribe an igneous origin to corundum enclosing a mineral with so much lower a fusing point as that of garnet.

A little consideration will, however, show that this objection has little validity. The temperature at which alumina is dissolved in a mixture of silicates has no necessary connection with the fusing point of alumina itself. That the magma from which these basic rocks consolidated was fluid at a temperature lower than the fusing point of the garnets, or at all events that the rock was in a state of aqueo-igneous fusion at a lower temperature, is evidenced by the condition of the beautifully crystallized garnets scattered through the basic rocks. At such temperatures, according to the experiments of Morozewicz, alumina may be largely dissolved in the basic fluid magma, and may slowly crystallize out from it. In this way we may conceive of the garnets being enclosed in a later formed corundum.

There are many points of resemblance between the association of minerals and the forms of crystallization of the Cowee Creek rubies and those of Burma. This will become apparent if we compare the figures now published with those given by Prof. Max Bauer of the Burma rubies.*

In considering the association of minerals described by Prof. Max Bauer in his paper, it should be remembered that the material on which that author worked came almost entirely from Sagyin, while those described by Mr. Barrington Brown and one of us were derived from the Mogok district, nearly 60 miles away. There is reason for concluding that the association of minerals in these two districts of Burma present some interesting points of difference.

Although, at first sight, the matrix of the Burma rubies (a crystalline limestone) may seem so different from that of the rubies of Cowee Creek (an amphibolite with garnets, and sometimes with a basic feldspar) yet a connection may still be shown to exist between the two cases. One of us has brought forward evidence to show† that the limestone of Burma has been formed by the slow alteration of a lime feldspar. Whether the corundum pre-existed in the highly-basic felspathic rock, however, or was formed at a later stage, there is no positive evidence to show. But the idea of its existence in the silicate rock originally is supported by the wonderfully corroded state of the corundum crystals.

The magma giving rise to pyroxene gneisses and granulites of Burma may not have differed greatly in composition from that giving rise to the amphibolites, eclogites, and basic gneiss

* Neues Jahrb. Min., etc., 1896, Bd. ii, Taf. vii.

† Phil. Trans., vol. clxxxviiA, 1896, pp. 151–228.

of North Carolina; and, in either case, corundum may have been formed by the separation of dissolved alumina. The great promise which is held out by the fine color and quality of many of the ruby crystals from this new locality would seem to warrant a continuance of the prospecting work lately inaugurated there, and it is to be hoped that the interesting problem of *the true origin of these rubies* may be definitely settled when the explorations on Cowee Creek shall have furnished fuller data and more conclusive evidence concerning the primary condition of the associated minerals and the nature and relations of the rocks of the district.

On the Crystallography of the Rubies from Macon County, North Carolina; by J. H. Pratt.

The ruby crystals from the Cowee Valley, Macon County, North Carolina, show a very wide variation in their development. Although many of the crystals are so striated that no crystallographic measurements were possible on the reflecting goniometer, the faces were readily identified by means of the contact goniometer. On some of the crystals the faces were bright and smooth, making them well adapted for measurement on the reflecting goniometer. The following references are to the figures on p. 380.

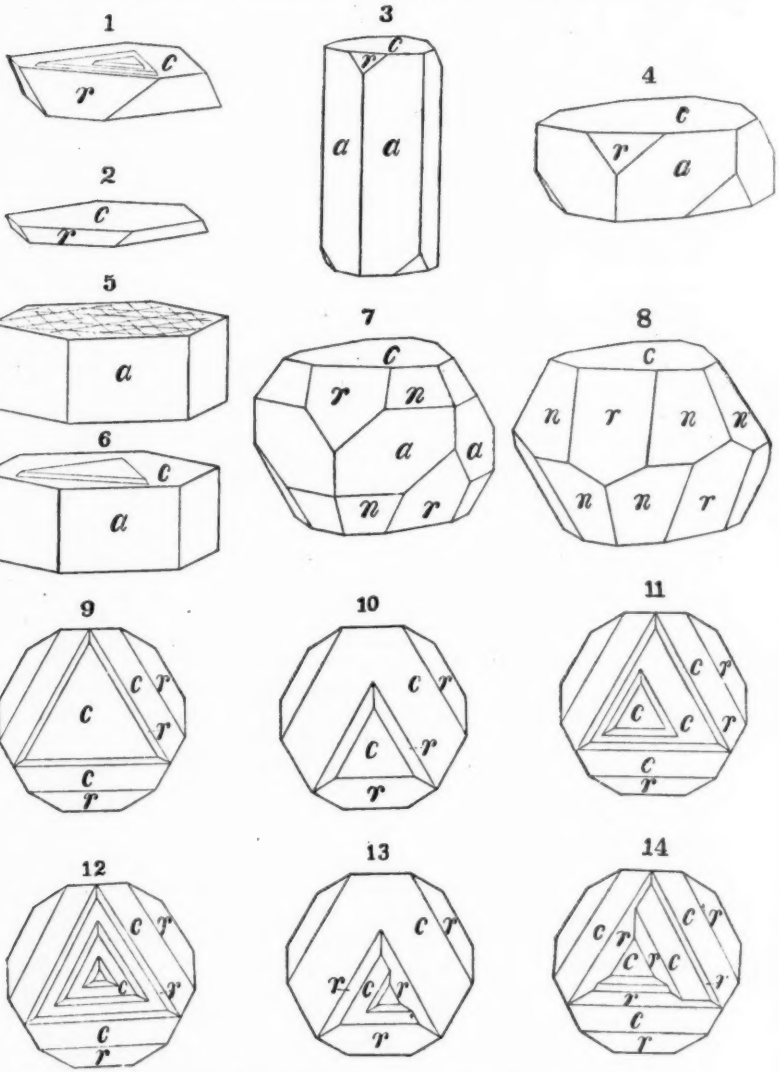
Among the crystals examined there were two common habits noticed, one, as shown in figs. 1 and 2, which is a combination of the base $c(0001)$ and the unit rhombohedron $(10\bar{1}1)$; the other, represented by figs. 3 to 6, where the prism $a(11\bar{2}0)$ is very prominently developed. The rhombohedral crystals vary from those where the base is largely developed, having a diameter of 12^{mm}, while the rhombohedron is only $1{\cdot}5^{mm}$, to some (fig. 1) which have the base and rhombohedron more equally developed. The majority of these crystals have, however, the base more largely developed, thus giving the crystals a flat tabular appearance. This rhombohedral development is very similar to that of the sapphires from Yogo Gulch, Montana, described by the author.*

On some of the prismatic crystals the prism reaches a length of nearly 15^{mm} in the direction of the c-axis, and has the rhombohedron but slightly developed (fig. 3), while on others the prism is very short and the rhombohedron sometimes is wanting, as represented in figs. 4 and 5.

Another habit of these crystals is shown in figs. 7 and 8. There the pyramid $n(22\bar{4}3)$ is well developed. This face was identified by means of the contact goniometer, the measurements approximating closely to the calculated angles. The

* This Journal, vol. iv, 1897, p. 424.

usual form of these crystals is shown in fig. 7, where the faces $c(0001)$, $a(11\bar{2}0)$, $r(10\bar{1}1)$ and $n(22\bar{4}3)$ are nearly equally developed.



oped. On some of the crystals the prism is very prominent, being 8^{mm} in length in the direction of the c-axis, while the pyramid is only 1·5^{mm}. On others the pyramid is only very

slightly developed. A few crystals were examined which showed only the presence of the base, the rhombohedron and the pyramid, as represented in fig. 8. The crystals, measuring up to 7^{mm} in diameter, were doubly terminated and nearly perfect in their development.

The crystals represented by fig. 7 are similar to those described by Max Bauer* from the Burma district, and are almost identical in form with a sapphire crystal figured by the author, from Emerald Bar, Cañon Ferry, Magher County, Montana.

Although both the basal and rhombohedral planes are very often striated, it is only on the basal planes that these are sharp and distinct and can be measured. The striations are parallel to the three intersections of the base c with the rhombohedron r, as shown in fig. 5.

A very common development that was noticed in nearly all the flat rhombohedral crystals, and on many of the prismatic crystals, is a repeated growth on the basal plane of the rhombohedron $r(10\bar{1}1)$ and the base $c(0001)$, as represented in figs. 1 and 6.

To better illustrate the variation in these growths, a series of figures (9 to 14) have been drawn in basal projection. In figs. 9 and 10, which represent the more common development of these repeated growths, there is but one secondary rhombohedron and base, which sometimes has one of its rhombohedron faces a continuation of one of the rhombohedron faces of the crystal. Figs. 11 and 12 represent repeated growths, the faces of which are separate and distinct from each other and from the faces of the main crystal. In the crystals represented by fig. 12, when the secondary growths are but slightly developed the basal plane of the crystal has the appearance of being striated with triangular markings. In figs. 13 and 14 there are represented a series of growths where a number of the rhombohedral faces coincide.

Some of the pyramidal crystals (figs. 7 and 8) also showed the development of the secondary growth of rhombohedron and base.

The thickness of the rhombohedron of the secondary growth varies from those that are so thin that they appear like striations to some that are 2^{mm} thick.

This same style of development has been described by Bauer† as occurring in the Burma rubies, and it has also been described by the author‡ as occurring on the Montana sapphires.

A few crystals were observed on which there was a secondary growth parallel to the prism $(11\bar{2}0)$.

* Neues Jahrb Min., 1896, ii, 197. † Loc. cit., p. 209.

‡ This Journal, vol. iv, 1897, p. 424.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Solidification of Hydrogen.*—Toward the end of 1898, as soon as Dewar had obtained two or three hundred cubic centimeters of liquid hydrogen, he attempted its solidification by boiling it under reduced pressure; but without result, no solid hydrogen being produced, even when the ebullition was effected under a pressure as low as ten millimeters. Subsequently he observed that a trifling leakage of air, such as it was almost impossible to prevent at this low temperature, produced, when the pressure was reduced below 60^{mm} a remarkable effect, causing a sudden solidification in the form of a gelatinous froth. At first he thought this was a sponge of solid air containing liquid hydrogen. But as it evaporated completely at this low pressure without leaving more than a trace of solid air, he concluded that it must be solid hydrogen. In confirmation of this view, he found that on increasing the pressure, and consequently the temperature, the solid melted when the pressure attained about 55^{mm}. Using a graduated tube attached to a closed balloon of about a liter capacity filled with pure hydrogen gas, he found that when this tube was immersed in boiling hydrogen, liquid hydrogen accumulated in it till the outside pressure reached 30 or 40^{mm} and the outside liquid became a solid froth. On inverting the apparatus, no flow could be observed along the tube; and in a strong light, the material in the lower part of this tube could be seen as a transparent ice. This solid hydrogen melted at a pressure of 55^{mm}. The temperature of fusion, determined with a hydrogen thermometer, was found to be about 16° absolute, under a pressure of 35^{mm}, theory indicating 16·7°. So that the practical limit of temperature which can be reached by the evaporation of solid hydrogen is 14° or 15° absolute. It is to be noted that the critical temperature of hydrogen being 30° to 32° absolute, its fusing point is one-half of this, i. e., 16°. The frothy appearance of the solid, as ordinarily produced, is due to the low density of the liquid and its rapid evaporation. These results would seem to destroy the hypothesis of the metallic character of hydrogen and to require its classification among the non-metallic elements.—*C. R.*, cxxix, 451–454, September, 1899. G. F. B.

2. *On Hydrazoic acid and its salts.*—Further researches have been made by Curtius and Rissom upon hydrazoic acid (HN_3) and its salts. The acid itself was prepared by distilling with sulphuric acid the lead nitride which is obtained as a by-product in the preparation of ammonium nitride. The aqueous solution thus obtained is quite permanent even on heating; but on boiling with strong acids it is decomposed with the evolution of gas. The ammonium nitride (NH_4N_3) is the most interesting of the

salts described. It is very volatile and explodes readily with great violence. But notwithstanding this the authors succeeded in determining its vapor density. The other salts arrange themselves according to their solubilities between the chloride and the bromide. In aqueous solution they behave as would be expected from the feebleness of the free acid. In the case of weaker bases, particularly alumina and iron oxide, strong hydrolysis takes place; so that in experiments made to form aluminum salts by double decomposition, alumina is precipitated. The non-dissociated part of the iron salts is colored deep red, like the acetates; but this substance is rapidly decomposed with the deposition of iron oxide.—*J. pr. Ch.*, lviii, 216–309, 1898; *Zeitschr. Phys. Chem.*, xxix, 174, May, 1899. G. F. B.

3. *On Argon and its Combinations.*—The earlier investigations of BERTHELOT to determine the possibility of causing argon to enter into combination with other bodies, have now been repeated under improved conditions. The argon was obtained from Ramsay, and after purification amounted to 455^{cc}. As in the previous experiments the argon, mixed with the substance to be acted upon, in either the gaseous, the liquid or the solid state, was placed in a silent discharge tube and submitted to the action of the electric spark from an induction coil giving discharges of 6 or 8^{mm}. Only from 5 to 10^{cc} of argon was used in each experiment, the substance added being gaseous, liquid or solid at pleasure. The first experiments were made with bodies of the fatty series, such as ethylene, aldehyde, acetone, petroleum ether, propionitrile and amylamine. No absorption of argon was observable. In the second set of experiments, bodies of the benzene series were tested, such as benzene, toluene, phenol, aniline and benzonitrile. A characteristic absorption of argon was observed, accompanied with a greenish luminescence visible in full daylight, and giving in its spectrum the lines of argon, of mercury, of carbon and of hydrogen; it being especially bright with benzene, toluene, benzonitrile and anisol. The author regards this result as due to the formation of a special substance phenylmercurargon, having only a very small vapor pressure. The action is in marked contrast with that on the fatty series. In a third set of experiments, cyclic compounds such as furfurol, thiophene, pyrrol and pyridine, were employed. The absorption of argon was much less, in some cases not even perceptible, and the light was feeble. Special experiments were then made with benzene and with carbon disulphide. In the case of benzene, the absorption of argon varied from 3 per cent. to 14 per cent, depending upon the relative amount of the two substances present and the time of exposure, the last result being obtained with equal volumes of argon and liquid benzene, the latter therefore in large excess. Benzene was found to dissolve 18 per cent of its volume of argon, carbon disulphide 6 per cent. The compound formed by argon with carbon disulphide is reddish in color and is solid. The absorption varied from 6 per cent. after six hours, to 7 after twenty

hours. By increasing the current pressure and so the temperature, the absorption was diminished. When hydrogen was added to the mixture, 10 per cent of argon was absorbed in 24 hours, all the hydrogen having disappeared. When benzene was thus added, the absorption was 9 per cent. It hence appears that to fix a molecule of argon (A_2) 34 molecules of carbon disulphide are required $(CS_2)_{34}$. In all cases a solid amorphous, reddish polymerized substance is formed; the polymerization of the bisulphide and the combination of hydrogen, of nitrogen or of argon proceeding simultaneously. The results obtained lead the author to suspect the existence of metallic argonides in those minerals which evolve argon under the action of acids, or even of hydrogen argonide. In a subsequent communication Berthelot gives the results of his experiments on the action of the electric discharge on argon mixed in one case with mercury-dimethyl, and in the other with mercury-diphenyl. No absorption took place in the first case, while in the second, owing to the production of phenylmercurargon, 6·5 per cent of argon was absorbed and the green luminescence was produced.—*C. R.*, cxxix, 71–84, 378–9, July, August, 1899. G. F. B.

4. *On Mercury in the Colloidal Condition.*—By reducing mercurous nitrate with stannous nitrate, adding ammonium citrate solution and filtering through an earthenware filter, LOTTERMOSER has succeeded in preparing colloidal mercury, which after drying is obtained in the form of brilliant silver-like masses which dissolve in water giving a dark brown solution. If this colloidal mercury is treated with dilute chlorine water, mercurous chloride is obtained, also in the colloidal state. In the same way the bromide and the iodide can be procured as colloids. The colloidal iodide appears as a deep red solution from which the iodide is rapidly deposited.—*J. pr. Ch.*, lvii, 484–487, 1898; *Zeitschr. Phys. Chem.*, xxix, 174, May, 1899. G. F. B.

5. *On Lithium-ammonium and Calcium-ammonium and the Amides of these Metals.*—It has been observed by MOISSAN that, like potassium and sodium, lithium and calcium dissolve in liquid ammonia with a blue color. But while the $NaNH_2$ decomposes at $-20°$ and KNH_2 at $-2°$, into metal and ammonia, the lithium and calcium compounds are permanent at the ordinary pressure and temperature, the $LiNH_2$ remaining unchanged up to $+70°$ and the $CaNH_2$ up to $+20°$; these compounds evolving so much heat in their formation that in the case of the lithium this metal is fused. On spontaneous evaporation as much ammonia becomes solid as corresponds to the formula $Li(NH_3)_3$. About 70°, there is formed crystallized $Li(NH_3)$; but by diminishing the pressure, this compound decomposes into metallic lithium and ammonia. Calcium ammonium corresponds to the formula $Ca(NH_3)_4$. Both lithium and calcium ammonium ignite spontaneously in the air. When instead of liquid ammonia, methylamine is brought in contact with lithium at $-20°$, a blue liquid is formed having approximately the composition $Li(NH_2CH_3)_3$. On evaporation in vacuo,

metallic lithium remains besides a blue crystalline compound $Li(NH_2CH_3)$ or lithium monomethylammonium, the NH_2CH_3 pressure being less than one atmosphere.—*C. R.*, cxxvii, 685–693, 1898; *ib.*, cxxviii, 26–30, 1899; *Zeitschr. Phys. Chem.*, xxix, 738, 747, September, 1899. G. F. B.

6. *On the Action of Potassammonium and of Sodammonium on Sulphur, Selenium and Tellurium.*—The action of the metallic ammoniums upon sulphur, selenium and tellurium has been studied by HUGOT. The apparatus used consisted of two large parallel tubes of glass united by a smaller tube containing glass wool. The metal and the metalloid are placed in one branch of the tube, previously filled with ammonia gas. The two branches are then sealed and connected with a reservoir containing the liquid ammonia, which collects in one of these branches. The alkali-ammonium dissolves in the excess of liquid giving a reddish-brown solution, which reacts upon the sulphur, selenium or tellurium present, giving rise to a white powder insoluble in the liquid (if the metalloid is present in excess) and which has the composition Na_2S, Na_2Se, or Na_2Te, formed with sodium or K_2S, K_2Se or K_2Te, when potassium is used. They are soluble in water free of air and give a colorless solution. When, however, the metalloid is in excess, the mono-compound which is first formed dissolves, the liquid becomes brown or violet and very limpid. On evaporating it at $-25°$, with subsequent lowering of pressure, the excess of ammonia is removed and a brown crystalline mass is left having the composition K_2Se_4 or Na_2Se_4 for selenium and similar formulas for sulphur and tellurium. These substances are all crystalline, are soluble in water but not soluble in liquid ammonia. They absorb ammonia gas.—*C. R.*, cxxix, 299–302; 388–390, July, August, 1899. G. F. B.

7. *A Short History of the Progress of Scientific Chemistry in our own times;* by WILLIAM A. TILDEN, F.R.S., Professor of Chemistry in the Royal College of Science, London. 8vo, pp. x, 276. New York, 1899 (Longmans, Green & Co.).—This excellent little book of Professor Tilden's had its origin in a course of lectures to working men such as the professors in the Royal School of Mines and the Royal College of Science have delivered annually for the last five and thirty years. Among the subjects treated in its ten chapters are Matter and Energy, the Chemical Elements, Standardization and Classification of Atomic Weights, Origin of the ideas of Valency, Synthetical and Stereo-Chemistry and the Liquefaction of Gases. The facts have been carefully selected and are attractively presented. The book will be of great service to the chemical student as a valuable résumé of the recent progress of Chemical Science. G. F. B.

8. *Refraction of the X-rays.*—A renewed interest has been taken in this subject. It seemed to H. HAGA and C. H. WIND, that the investigations of Fomm, Wied. Ann., lix, p. 350, 1896, appeared to open a way for the determination of a possible refraction. It was shown by P. G. Tiddens, Beibl., xxi, p. 603, 1897, that the Fomm

bands were not produced by refraction. Haga and Wind set themselves to determine what causes the Fomm bands and whether there are refraction phenomena in the case of the X-rays. The Fomm bands or lines are maxima produced by a difference of illumination on a surface lighted through a slit, and the phenomenon was studied as early as 1866 by E. Mach, and the results were published in the Proceedings of the Vienna Academy of Sciences under the title "Ueber die Physiologische Wirkung räumlich-vertheilter Lichtreize." A study of this pseudo diffraction effect showed the authors that their earlier work on the wave nature of the Röntgen rays fell to the ground, and that previous investigations in which the distance between the Crookes tube and the sensitive plate was as much as 24 meters and the time of exposure 80 hours, and in which double-flowed plates and strengthening screens were used, are worthless. The authors, moreover, are convinced that the eventual wave length of the X-rays must be of far smaller value than has been supposed. New experiments were then undertaken to test the question whether there are true refraction effects with X-rays. The authors believe that such effects will be found and that the wave length of the rays lies under a tenth of $\mu\mu$.

C. H. Wind also discusses the question whether the refraction phenomena studied by Haga and himself are due to certain vibrations of the source of light 3000 times smaller than the time of vibration of yellow light, and that the emission of the X-ray system must be ascribed to a nature of vibration entirely different from that of ordinary light. He comes after an analytical discussion of this question to the conclusion that this conclusion is not justified (Wied. Ann., No. 8, 1899, pp. 884–901).

M. Maier has also investigated the question of the refraction of the X-rays and states that he has discovered interference phenomena which indicate the wave nature of these rays. He finds wave lengths $0{\cdot}000015^{mm}$ in length. His experiments do not decide the question of the transversality of these waves, for no polarization phenomena were in evidence.— *Wied. Ann.*, No. 8, 1899, pp. 903–916. J. T.

9. *Radio-active substances.*—E. DE HAËN has discovered two preparations of uranium earth which possess the property of exciting X-rays in a remarkable degree. Preparation A shows the phenomenon of the Becquerel rays; excites fluorescence of barium platinum-cyanide screens, even through substances opaque to light; acts upon photographic plates; makes air conducting for electricity, and has, moreover, the hitherto undiscovered property of being self-luminous. Preparation B proves to have in general the peculiarities of preparation A. The excitation of a screen is more intense, the self-lighting is much weaker.— *Wied. Ann.*, No. 8, p. 902. J. T.

10. *Physikalische Zeitschrift*, No. 1–2, pp. 1–38, Leipzig (S. Hirzel).—Physicists will be interested in the appearance of the *Physikalische Zeitschrift*, of which the first number (1 and 2) was

issued on the 1st of October. This new periodical is to be conducted by Dr. E. Riecke and Dr. H. Th. Simon of Göttingen, aided by a considerable staff of co-workers, for the preparation of abstracts. It is to be issued in weekly numbers at a cost of 5 marks for three months. As a prompt means by which physicists may present the results of their work, it will doubtless prove of great value and contribute much to the progress of science. The portion devoted to abstracts and book notices also promises to be carefully and thoroughly conducted.

II. Geology and Natural History.

1. *On Geological Time.*—The address of Sir Archibald Geikie, before the Geological Section of the British Association at the recent Dover meeting, was an able presentation of the profound problem of geological time. He opened with a historical summary of the successive phases of the discussion, beginning with the writings of Hutton, to whom modern geology owes so much. The conclusion of Hutton's philosophy is thus stated, "that the history of the earth occupied prolonged though indeterminate ages in its accomplishment." The Uniformitarian School, following, founded on the teachings of Hutton and Playfair, came to believe that an absolutely unlimited extent of time was at the disposal of geologists. In 1862, however, the discussion of the subject was first undertaken from the physical side, when Sir William Thomson (Lord Kelvin), in his paper on the secular cooling of the earth, announced the conclusion that the age of the earth must be more than 20 millions but less than 400 millions of years. Since that time the physical arguments have been restated and reargued by Lord Kelvin and others, the latest conclusion of the same physicist (Victoria Institute address of 1897, see this Journal, vii, 160), being that the age "was more than twenty and less than forty millions of years and probably much nearer twenty than forty."

This conclusion, however, has not been universally accepted by physicists, for example, Professor Perry in 1895 closed a discussion intended to show the uncertainty of the physical data upon which the estimate was based, by the remark: "It is to be observed that if we exclude everything but the arguments from mere physics the *probable* age of the earth is much less than any of the above estimates; but if paleontologists have good reasons for demanding much greater times, I see nothing from the physicist's point of view which denies them four times the greatest of the estimates."

After this historical summary, the writer goes on to protest vigorously against the ignoring of the evidence adduced by geologist and paleontologist which has often characterized the discussions of the physicist. He writes: "It is difficult satisfactorily to carry on a discussion in which your opponent entirely ignores your arguments, while you have given the fullest attention to his.

In the present instance, geologists have most carefully listened to all that has been brought forward from the physical side. Impressed by the force of the physical reasoning, they no longer believe that they can make any demands they may please on past time. They have been willing to accept Lord Kelvin's original estimate of 100 millions of years as the period within which the history of life upon the planet must be comprised ; while some of them have even sought in various ways to reduce that sum nearer to his lower limit. Yet there is undoubtedly a prevalent misgiving, whether in thus seeking to reconcile their requirements with the demands of the physicist they are not tying themselves down within limits of time which, on any theory of evolution, would have been insufficient for the development of the animal and vegetable kingdoms."

Going on to discuss the evidence as to the rate of change and intensity of action of geological changes in earlier geological times as compared with the more recent, he says: "They [geologists] have been unable to discover any indication that the rate of geological causation has ever, on the whole, greatly varied during the time which has elapsed since the deposition of the oldest stratified rocks. They do not assert that there has been no variation, that there have been no periods of greater activity, both hypogene and epigene. But they maintain that the demonstration of the existence of such periods has yet to be made. They most confidently affirm that whatever may have happened in the earliest ages, in the whole vast succession of sedimentary strata nothing has yet been detected which necessarily demands that more violent and rapid action which the physicists suppose to have been the order of nature during the past.

"So far as the potent effects of prolonged denudation permit us to judge, the latest mountain-upheavals were at least as stupendous as any of older date whereof the basal relics can yet be detected. They seem, indeed, to have been still more gigantic than those. It may be doubted, for example, whether among the vestiges that remain of Mesozoic or Palæozoic mountain-chains any instance can be found so colossal as those of Tertiary times, such as the Alps. No volcanic eruptions of the older geological periods can compare in extent or volume with those of Tertiary and recent date. The plication and dislocation of the terrestrial crust are proportionately as conspicuously displayed among the younger as among the older formations, though the latter, from their greater antiquity, have suffered during a longer time from the renewed disturbances of successive periods." And further: "It is thus abundantly manifest that even in the most ancient of the sedimentary registers of the earth's history, not only is there no evidence of colossal floods, tides and denudation, but there is incontrovertible proof of continuous orderly deposition such as may be witnessed to-day in any quarter of the globe. The same tale, with endless additional details, is told all through the stratified formations down to those which are in the course of accumulation at the present day."

A consideration of the paleontological evidence shows how strong an argument can be make on this side. He concludes: "Until, therefore, it can be shown that geologists and paleontologists have misinterpreted their records, they are surely well within their logical rights in claiming as much time for the history of this earth as the vast body of evidence accumulated by them demands. So far as I have been able to form an opinion, one hundred millions of years would suffice for that portion of the history which is registered in the stratified rocks of the crust. But if the paleontologists find such a period too narrow for their requirements, I can see no reason on the geological side why they should not be at liberty to enlarge it as far as they may find to be needful for the evolution of organized existence on the globe. As I have already remarked, it is not the length of time which interests us so much as the determination of the relative chronology of the events which were transacted within that time. As to the general succession of these events, there can be no dispute. We have traced its stages from the bottom of the oldest rocks up to the surface of the present continents and the floor of the present seas. We know that these stages have followed each other in orderly advance, and that geological time, whatever limits may be assigned to it, has sufficed for the passage of the long stately procession.

"We may, therefore, well leave the dispute about the age of the earth to the decision of the future. In so doing, however, I should be glad if we could carry away from it something of greater service to science than the consciousness of having striven our best in a barren controversy, wherein concession has all to be on one side and the selection of arguments entirely on the other. During these years of prolonged debate I have often been painfully conscious that in this subject, as in so many others throughout the geological domain, the want of accurate numerical data is a serious hindrance to the progress of our science. Heartily do I acknowledge that much has been done in the way of measurements and experiments for the purpose of providing a foundation for estimates and deductions. But infinitely more remains to be accomplished. The field of investigation is almost boundless, for there is hardly a department of geological dynamics over which it does not extend. The range of experimental geology must be widely enlarged, until every process susceptible of illustration or measurement by artificial means has been investigated. Field-observation needs to be supplemented where possible by instrumental determinations, so as to be made more precise and accurate, and more capable of furnishing reliable numerical statistics for practical as well as theoretical deductions."

The writer closes by an enumeration of some of the different lines of investigation which, if followed out, might be expected to lead to more definite knowledge in regard to this fundamental question, and suggests that the coming International Geological Congress to be held in Paris in 1900, might well organize a system of combined observations looking to this end.

2. *An Estimate of the Geological Age of the Earth;* by J Joly, University of Dublin.—The latest contribution to the subject ably argued by Sir Archibald Geikie at the meeting of the British Association (see above), is that by Professor J. Joly in a paper published in vol. vii of the Scientific Transactions of the Royal Dublin Society, September, 1899. In this interesting memoir the author discusses the geological age of the earth since the formation of the ocean, basing his calculations upon the time required to supply to it the amount of sodium now present in the water. He starts with the assumption of the Uniformitarian, that the processes now going on may be considered to have continued essentially as at present for the whole period in the past here concerned. The basis on which his argument is placed will be understood from the following paragraphs.

"In the method of approaching the question of the Age of the Earth advanced in this paper, the foregoing tenet* requires only acceptation in part—that part of it which refers to the removal of the land surface by *solution*. It has to be accepted as a preliminary step that this, on the whole, has been constant. Herein are involved a constancy, within certain fairly wide limits, of rainfall over the land areas; a constancy within fairly wide limits (which can roughly be defined) of the exposed land area, and a constancy in the nature and rate of solvent actions going on over the land surfaces. The grounds on which this amount of uniformity is accepted are given in this paper. One other tenet must be accepted, that the primeval ocean—that formed on first condensation of the water upon the land—did not contain the amount of dissolved sodium now entering so largely into its constitution. The grounds upon which this is claimed are also dealt with further on.

"How can these data be used to determine what may be termed the Epigene Age of the Earth? In the sea or in its deposits those elements are recognizable which enter also into the constituents of the solid part of the Earth's crust. In the rivers these elements are also recognizable as being continually poured into the ocean. Very accurate estimates of the quantities of these elements in the ocean exist. The dissolved contents of many of the great rivers of the Earth and the mean composition and mean volume of the entire river discharge have been estimated.

"Now if any of the elements entering the ocean is not again withdrawn, but is, in a word, 'trapped' therein, re-appears as no extensive marine deposit, and is not laid down sensibly upon its floor; and if the amount of Uniformity already defined is accepted, evidently in the rate of annual accretion by the ocean from the rivers of this substance and the amount of it now in the ocean, the whole period since the beginning of its supply can be estimated.

*[That the rate of removal of the subærial land surface—by solution and transportation—has been on the whole uniform.]

"Such an element is sodium. We take for this calculation the element alone, thus avoiding the obscure question of its ionization, which does not concern the issue. The quantity of sodium now in the sea, and the annual rate of its supply by the rivers, lead, it will be seen, to the deduction that the age of the Earth is 99 million years. Certain deductions from this are—it will be shown —warranted, so that the final result of this paper will be to show that the probable age is about 89 million years. Also, that this is probably a major limit, and that considerable departure from uniformity of activities could hardly amend it to less than 80 million years."

The actual calculation is very simple, since in the first place the total mass of the ocean is known approximately and also its composition, hence the total amount of sodium now present in it is obtained; further, the total amount of water discharged by the rivers into the ocean is known, with their average percentage of solid matter, sodium included, and this gives the mass of sodium annually added to the ocean. The quotient obtained is 99,400,000 years.

A minute discussion is given as to the probable original condition of the ocean and the state in which the chlorine now combined as sodium chloride probably existed. It is concluded that of the total chlorine in the original ocean, probably some 14 per cent may have existed as sodium chloride derived from the rapid denudation of the original rocks. This conclusion is based on the view that the chlorine now in the ocean must have been originally free in the atmosphere and hydrosphere, probably combined with hydrogen. The first result, (1) 99·4 millions of years, obtained, as stated, on the assumption that no free acid existed in the primeval atmosphere and that the total river supply of sodium was derived at a uniform rate from the rocks, is now (2) reduced to 86·9 million, assuming that the free acid in the original atmosphere (see above), less that subsequently supplied by rivers, attacked the original rocks and became neutralized in a negligible time. This again (3) becomes 89 millions if a period of acid denudation at a rate five times the average rate of present subærial denudation is assumed. And finally (4) the result 89·3 millions of years is obtained in a fourth assumption that 10 p. c. of the sodium chloride in the river discharge was derived from the ocean.

Account is taken of the deposits of rock salt at various points, as, for instance, the salt range of the Punjab; but it is shown that the amount involved is relatively so small as not to seriously affect the problem. Other points are also considered, as to the probable uniformity of denudation by solution dependent upon land area and rainfall; also the solvent denudation of the ocean itself; but for the details of these, reference must be made to the original memoir.

One interesting relation brought out in the discussion is that existing between the soda (Na_2O) and potash (K_2O) in the aver-

age igneous and eruptive crust-rock as compared with that in sediments. The ratio, as obtained by Clarke, is 3·61 : 2·83, or $Na_2O : K_2O = 1·29 : 1$. From rock analyses quoted by Rosenbusch, the ratio 1·22 is obtained. For sedimentary rocks, however, the ratio (from Rosenbusch) 0·59 : 1 is obtained. The author discusses the bearing of these facts and finally concludes that "whereas the sodium compounds tend to accumulate in the waters of the ocean, the potassium compounds tend to be stored in the solid form or retained upon the land; and that to the causes which bring about this separation, and not to any differences in part processes of denudation, the remarkable scarcity in the ocean of potassium relatively to sodium is to be ascribed."

As connected with the same subject he notes that while roofing slates of Cambrian or Silurian age (quoting Rosenbusch and Clarke) contain 4·1 to 5·6 p. c. alkalies, and Devonian slates have 3·04 to 3·54; recent sediments contain a much smaller amount, e. g. 1·47 p. c. in the case of the Rhine, 1·96 for the Nile, etc.

3. *Recent Publications of the United States Geological Survey*, Charles D. Walcott, Director.—The following volumes have been recently issued by the U. S. Geological Survey:

NINETEENTH ANNUAL REPORT FOR 1897–98. Part I, *Director's Report*, including Triangulation and Surveying (see this Journal, vol. vii, p. 166).

Part IV, *Hydrography*, F. H. NEWELL, Chief of Division. Pp. viii, 814 with plates I to CXVIII. The results of the recent work in this highly important department of the Survey are now presented by themselves in a single volume of generous dimensions. For ten years past observations have been systematically carried on, having as their object the collection of data in regard to the fluctuation of the waters of prominent streams throughout the United States. The importance of the knowledge thus gained both from an economic and a scientific standpoint can readily be estimated. The opening chapter of the present volume by F. H. Newell, assisted by various observers (pp. 1–633), explains with numerous illustrations the methods of work, and then goes on to give the results of measurements of different rivers taken in natural geographical order. Among the special reports included may be mentioned one by Dwight Porter (pp. 34–111) on the streams of Maine and another by J. P. Lippincott (pp. 540–632) on the water supply of San Bernardino valley. The latter report is especially interesting as giving with many illustrations an account of the method of storing and distributing water, and the striking results so obtained, in a region which depends almost entirely upon artificial irrigation. Special chapters on the rock waters of Ohio, by Edward Orton (pp. 633–718, plates LXXI–LXXIII), and on the geology and water resources of Nebraska west of the 103d meridian by N. H. Darton (pp. 710–780, plates LXXIV–CXVIII) also certain much interesting matter.

Part VI. *Mineral Resources of the United States for* 1897, DAVID T. DAY, Chief of Division. This report, the fourteenth

of the series, appears in two volumes, each separately paged and indexed. The first (pp. 651) contains the Metallic Products with coal and coke, the second (pp. 706) Non-metallic Products except coal and coke. The value and scope of this report, to which many specialists have contributed, are too well known to need further comment here.

MONOGRAPHS: XXXI, *Geology of the Aspen Mining District, Colorado*, by JOSIAH EDWARD SPURR, pp. xxxv, 60. With an Atlas containing folio plates. This report will be noticed later.

Also XXIX by B. K. EMERSON and XXXI by the late JOHN STRONG NEWBERRY; both of these are noticed below.

BULLETIN, No. 162. *Bibliography and Index of North American Geology, Paleontology, Petrology and Mineralogy* for 1898, by FRED BOUGHTON WEEKS. The value of this series is much increased by the admirable promptness with which the successive numbers appear.

4. *Geology of Old Hampshire County, Massachusetts, comprising Franklin, Hampshire, and Hampden Counties*, by BENJAMIN KENDALL EMERSON, pp. 1–782, plates i–xxxv, 1898. U. S. Geological Survey, Charles D. Walcott, Director. Monograph XXIX.—This elaborate description of the geology of central Massachusetts was begun in 1873, and thus contains the mature opinions of the author, based on a detailed study of the region. The classification of the rocks, which (except the Triassic sandstone) are crystalline limestones, granite schists, gneisses and diabases, is constructed on a chronologic basis.

The following general section of the rocks in the Berkshire hills and Connecticut valley will indicate the author's interpretation and the names adopted in the report:

Trias.
- Black Rock diabase (intrusive).
- Chicopee shale.
- Longmeadow sandstone.
- Granby tuff.
- Mount Holyoke diabase (interbedded).
- Sugar Loaf arkose.
- Mount Toby conglomerate.
- *Unconformity.*

Eruptives, mostly post-Carboniferous.
- Granite.
- Granitite.
- Pegmatite.
- Albitic granite.
- Tonalite.

Carboniferous (no representative in the region).

Devonian.
- Bernardston mica-schist.
- Bernardston amphibolite.
- Bernardston quartzite.
- Bernardston limestone.
- Vernon gneiss.
- *Unconformity.*

Upper Silurian.
- Leyden argillite.
- Conway dark corrugated mica-schist with garnets.
- Goshen flaggy biotitic muscovite-schist with quartzite and limestone beds.
- *Unconformity.*

Lower Silurian.
- Hawley actinolitic chlorite-schist, amphibolite, pyrite, and hematite beds.
- Savoy chloritic sericite-schist.
- Chester amphibolite, with emery, serpentine, steatite, and saxonite.
- Rowe quartzose sericite-schist with amphibolite beds.
- Hoosac albitic sericite schist.

Cambrian.
- Cheshire white granular quartzite.
- Becket white conglomerate-gneiss.
- *Unconformity.*

Algonkian.
- Washington blue quartz-gneiss.
- Tyringham stretched biotite-gneiss.
- East Lee black biotite-hornblende-gneiss.
- Hinsdale coarse chondrodite-limestone.
- Hinsdale granitoid gneiss. W.

5. *The Later Extinct Floras of North America*, by JOHN STRONG NEWBERRY; A Posthumous Work, edited by ARTHUR HOLLICK, pp. i–xvii, 1–295, plates i–xlvii, 1898. U. S. Geological Survey, Charles D. Walcott, Director, Monograph XXXV. —In this volume are included illustrations of 174 species of Cretaceous and Tertiary plants, gathered from 52 localities of North America, together with such notes and descriptions as were found among his manuscript after Dr. Newberry's death.

Figures of some of the species have been previously distributed and names (MSS.) published, but in the present work all unpublished descriptions and notes found among the author's papers are edited and their reference to the figures indicated by the editor, Dr. Hollick, whenever clear, and whenever uncertain with the editor's comments. W.

6. *Geological Survey of New Jersey, Annual Report of the State Geologist for the Year* 1898, pp. 1–244 and 1–100, plates i–v and i–xxii, 1899.—Besides the customary reports on various geological problems, an appendix of more than ordinary interest is furnished by GIFFORD PINCHOT on "A study of Forest Fires and Wood Production," illustrated by numerous photographic reproductions of the effects of the fires upon the forests in general and the individual trees of various ages. W.

7. *Report on the Surface Geology and Auriferous Deposits of Southeastern Quebec*, by R. CHALMERS, pp. 5–160, plate i. Geological Survey of Canada, Annual Report, vol. X, 1898, G. M.

Dawson, Director. Part J, No. 670.—The gold-bearing region described in this report extends from Memphremagog Lake on the west, to the Etchemin River and Township of Ware on the northeast, and from the crystalline range of mountains nearest the St. Lawrence (the Sutton Mountain anticline) southeastward to the International boundary.

The author concludes from his study of the region that the "original source of this precious metal was in the oldest rocks of the 'Eastern Townships,' namely the pre-Cambrian or Huronian (?) of the three mountain ranges which traverse it. The Cambrian and Cambro-Silurian rocks are probably composed largely of materials derived from the pre-Cambrian in their disintegration and waste, and the gold they contain, as well as that met with in the alluviums derived from them, probably owes its origin likewise to the same source. Concentrating processes have been in operation ever since. During the formation of the Cambrian and Cambro-Silurian rocks there may have been some mechanical concentration of the gold in these, as the sediments which were derived from the pre-Cambrian in Cambrian and Cambro-Silurian times would naturally contain it in a fine state of division. It is difficult except on this supposition to account for its presence in some areas and its scarcity or absence in others. But the chief concentration seems to have been in some of the quartz veins at a later stage in areas of eruptive diorites and other intrusive rocks, and still later in the alluviums of the river-valleys during the wear and waste of the land surface." W.

8. *The History of the European Fauna*, by R. F. Scharff, pp. 1–364, 1899 (The Contemporary Science Series, Walter Scott).—This book is a study in the origin and migration of the component elements of a living fauna. The present fauna of Britain is recognized as having its origin in migration to the region of an Arctic, a Siberian, an Oriental, a Lusitanian (southwest Europe) and an Alpine fauna. Regarding the time and order of these migrations, the author says, "there is considerable difference of opinion on this subject. Some believe that the British fauna is altogether post-glacial; a few think that it is partly so and the remainder glacial; others again hold that a portion is pre-glacial and the rest glacial and post-glacial. Those who have studied the subject most closely feel convinced that the southwestern or Lusitanian fauna, and also the flora, must have arrived before the Glacial period and survived the latter in these Islands. It seems reasonable to suppose, therefore, that the climate cannot have been very severe during the so-called Ice-Age. This Lusitanian fauna must be looked upon as the oldest portion of the British fauna. The Alpine and Oriental migrations arrived next. After these came the Arctic, and finally the Eastern or Siberian. As the fossil evidence is most complete with regard to the last, we are able to determine with precision not only the direction whence this migration came, but approximately its geological age. It arrived in Germany from the east after the deposition of the

lower bowlder-clay. Since the bowlder-clay is looked upon as a glacial deposit, the Siberian migration reached Central Europe after the first portion of the Glacial period had passed. In England it makes its first appearance in the Forest-Bed, which would therefore correspond to the 'Loess' formation of Central Europe. All the other migrations are older than the Siberian. They must therefore have come to Great Britain during the earlier part of the Glacial period or before it." W.

9. *The Geology of the Coolgardie Gold field;* by TORRINGTON BLATCHFORD, Assistant Government Geologist. Bulletin No. 3, Western Australia Geological Survey, A. Gibb Maitland, Government Geologist. Perth, 1899.—The Coolgardie gold field is remarkable for its rapid development—it was discovered in 1892—and for the richness of much of the ore. The prevailing rocks are designated as diorite with adjacent hornblendic and talcose schists, both intersected by numerous acid igneous dikes; a mass of granite is central in the district. Superficial deposits, in part "ironstone gravel," cover much of the region. The gold has been largely obtained from "gold reefs" intersecting the schists chiefly and dipping eastward at an angle of 60° to 80°. In addition gold has been obtained also from lenticular ferruginous patches and altered schists adjoining the igneous dikes. The alluvial deposits have also yielded much gold. The gold exported in 1894 amounted to 105,330 oz. and 1898 to 127,227 oz. The development of the region is much retarded by the deficient water supply. The average rainfall for the five years from 1894 to 1898 was only 7·01 inches, and artesian wells, though repeatedly tried, have not proved successful.

A large colored geological map of the region, on a scale of 8 inches to the mile, has been issued, in addition to the smaller one accompanying the report.

10. *Mineral Resources of Kansas for* 1899, by ERASMUS HAWORTH. Annual Bulletin of the University Geological Survey of Kansas, pp. 127, 1899, Lawrence, Kansas.—This second annual bulletin on the mineral resources of Kansas has recently been issued and contains an account of the lead and zinc mining, coal, oil, and gas, gypsum, building stone and clays, hydraulic cement, and salt.

The *salt* industry is of especial importance in the State, and the account here given of its discovery in 1887–88 and its rapid development is very interesting. Prof. Haworth, speaking of the geology of the Kansas salts, distinguishes between (1) the salt of salt marshes and of salt plains, chiefly in the northern part of the State, where the salt has been obtained from the shales of the Dakota formation; and (2) the rock salt of Central Kansas, which has been located in "salt shales" of the Permian. The thickness of the salt deposits diminishes eastward, though the exact extent on the west side of the salt lake from which the material was precipitated is as yet unknown. In a north and south direction the known salt beds cover a wider area, reaching from Anthony to

Kanopolis, thinning out northward. Thus the salt beds at Kingman are 415 feet in thickness; at Hutchinson, 380 feet; at Lyons, 275 feet, and at Kanopolis only 250. At this rate they would disappear entirely before the north line of the State is reached. It is a remarkable fact that the usual gypsum deposits do not seem to be present at localities just named, though largely represented to the northeast in Marshall County. In regard to this, Professor Haworth writes :

"It is difficult to understand how such extensive deposits of salt could be formed without a larger amount of gypsum being formed underneath them. The records of the wells at Kanopolis, Lyons, Hutchinson, Kingman and Anthony contain no reference to gypsum immediately underlying the salt beds. The question is as to what became of the calcium sulphate held in solution by the ocean water from which the rock salt was obtained. It is barely possible that during the period of the formation of the Marshall County gypsum the inland sea did not reach southward to the salt beds area, and that after gypsum was principally precipitated out of the enclosed ocean water and before concentration was carried far enough to precipitate the salt, surface movements resulted in draining this partially purified water southward over new areas from which fresh ocean water was excluded, thus permitting the continued evaporation to deposit the salt now found in the salt beds from the same water from which the Marshall County gypsum was produced. It is known that the Permian rocks, in general, become quite thin northward, entirely excluding the upper members of the Permian. So far as this has a bearing on the subject, it would tend to favor the view just expressed."

11. *Catalogus Mammalium tam viventium quam fossilium a* Doctore E. L. Trouessart, Parisiis. Nova Editio (Prima completa). Fasciculus VI. Appendix (Addenda et Corrigenda). Index alphabeticus. pp. 1265–1469. Berlin, 1899 (R. Friedländer & Sohn).—The sixth and concluding part of this highly important work has recently been issued. It consists of an Appendix (pp. 1265–1360) containing Addenda and Corrigenda; also an exhaustive alphabetical index (pp. 1361–1469). The thoroughness with which the whole undertaking has been carried through makes it an invaluable book of reference to all zoologists.

12. *Das Tierreich. Eine Zusammenstellung und Kennzeichnung der rezenten Tierformen.* Herausgegeben von der Deutschen Zoologischen Gesellschaft. Generalredakteur, Franz Eilhard Schulze. 5. Lieferung. *Protozoa.* Redakteur: O. Bütschli. *Sporozoa* par Alphonse Labbé. pp. 180 with 196 figures. Berlin, 1899 (R. Friedländer & Sohn).—Another work of similar exhaustive character to the above and broader scope is "Das Tierreich," published by the German Zoological Society. Earlier numbers have been repeatedly noticed in these pages. The present part, No. 5, contains the Sporozoa by Alphonse Labbé,

conservateur of the zoological collections of the Sorbonne at Paris. The classified species are briefly characterized with numerous references to authorities. Many illustrations accompany the text.

13. *Zoological Results based on Material from New Britain, New Guinea, Loyalty Islands and elsewhere*, collected during the years 1895, 1896, and 1897; by ARTHUR WILLEY. Part III, (May, 1899), pp. 207–356. Cambridge, 1899 (University Press).—Parts I and II of this work have already been noticed; the third part, recently issued, contains the following papers: Orthogenetic variation in the shells of Chelonia, by Hans Gadow; pp. 207–222, plates xxiv–xxv. Enteropneusta from the South Pacific, with notes on the West Indian Species, by Arthur Willey; pp. 223–334, plates xxvi–xxxii. A collection of Echiurids from the Loyalty Islands, New Britain and China Straits, with an attempt to revise the group and to determine its geographical range, by Arthur E. Shipley; pp. 335–356, plate xxxii.

14. *Proceedings of the Fourth International Congress of Zoology.* Cambridge, 22nd–27th August, 1898. Edited by ADAM SEDGWICK, M.A., F.R.S; pp. xv and 432 with 15 plates. London, 1899 (C. J. Clay & Sons).—This valuable volume has recently been issued and contains, in addition to the account of the meetings of the Congress at Cambridge in 1898, a large number of papers presented at that time, with the discussions which accompanied their reading.

15. *The Birds of Eastern North America: Water Birds.* Part I. Key to the Families and Species. By CHARLES B. CORY, Curator of the Department of Ornithology in the Field Columbian Museum. Pp. ix, 142.—This excellent and liberally illustrated volume appears as a special edition printed for the Field Columbian Museum.

16. *A Hand-list of the Genera and Species of Birds;* by R. BOWDLER SHARPE, LL.D. Vol. I, pp. xxi and 303, London, 1899.—This recent addition to the Catalogues published under the auspices of the British Museum, including species both recent and fossil, has been carefully prepared by Dr. Sharpe of the Zoological Department. Many ornithologists at home and abroad have contributed to its accuracy and completeness.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *American Physical Society.*—A meeting of the recently organized American Physical Society was held in Fayerweather Hall, Columbia University, New York City, on October 28th. The program announces the presidential address delivered by Professor Henry A. Rowland and papers read by various of the members. Four regular meetings of the Society are proposed for each year, ordinarily to be held in New York; the annual meeting is appointed for the last week of December. The Society will issue a Bulletin containing reports of the meetings with notices of papers read or presented. The Secretary of the Society is Professor Ernest Merritt.

2. *Transactions of the American Microscopical Society*, edited by the Secretary. Twenty-first annual meeting held at Syracuse, N. Y., August 30th, 31st, and September 1st, 1899. Vol. xx, pp. 369 with 32 plates.—The latest volume of the Transactions of the American Microscopical Society, just published, contains the usual number of valuable papers. Among the more extended of these may be mentioned the following: Contributions to the histogenesis of the Caryophyllales, I, by F. E. Clements, pp. 97–164, with plates viii to xxv; the North American species of the genus Atax (Fabr.) Bruz, by R. H. Wolcott, pp. 193–260, with plates xxviii–xxxii; Fresh water investigations during the last five years, by Henry B. Ward, pp. 261–336.

A paper by A. Mansfield Holmes (pp. 177–188) gives the results of some observations as to the effect of altitude on the red blood cells. It is shown that a sudden change from a low to a high altitude produces a rapid increase in the number of red cells, and a descent to a lower altitude, a rapid decrease. The former change, however, takes place immediately, the number continuing to increase during a residence on a mountain; but the diminution on descent, though rapid, is not so pronounced as the rate of increase. The effect of altitude is thus explained: that the increasing need of oxygen at higher points calls for greater activity of the total volume of red cells and brings, therefore, into activity many which under different conditions would remain more or less quiescent in deeper portions of the body.

3. *A Primer of Forestry.* Part I: The Forest. By GIFFORD PINCHOT; pp. 88 with 47 plates. Washington, 1899. Bulletin No. 4, U. S. Department of Agriculture, Division of Forestry.—This little book, with its numerous illustrations, presents in very attractive form the subject of forestry newly developed in this country, and which, under the guidance of Mr. Pinchot and others, it is hoped will yield important fruit. The author shows how a forest is to be regarded as an organic whole, and traces its progress through the time of full maturity to the inevitable end. An interesting chapter is that devoted to the numerous enemies of the forest, as fire, the reckless use of the axe, insects, and others.

4. *Statistical Methods with special reference to Biological Variation;* by C. B. DAVENPORT, Harvard University. New York, 1899 (John Wiley & Sons).—This little volume contains in very concise and clear form a series of mathematical tables, formulas, etc., likely to prove valuable to the working biologist in his statistical work on recently developed lines. The subjects of the preliminary chapters are: The methods of measuring organisms; the seriation and plotting of data and the frequency polygons; the classes of frequency polygons; correlated variability. The mathematical tables follow, accompanied by concise explanations as to their use.

5. *Harper's Scientific Memoirs*, edited by J. S. AMES, Ph.D. Volumes v, vi, and vii of this valuable series (see vol. vi, pp. 199, 504) have been recently issued. Their subjects are as follows:

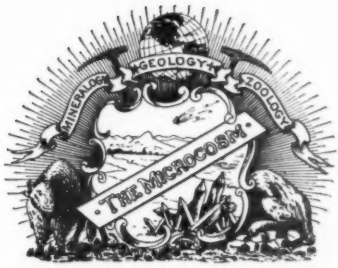
The Laws of Gases. Memoirs by Robert Boyle and E. H. Amagat. Translated and edited by Professor Carl Barus.

The Second Law of Thermodynamics. Memoirs by Carnot, Clausius, and Thomson. Translated and edited by Dr. W. F. Magie.

The Fundamental Laws of Electrolytic Conduction. Memoirs by Faraday, Hittorf, and F. Kohlrausch. Translated and edited by Dr. H. M. Goodwin.

OBITUARY.

EDWARD ORTON, Professor of Geology in the Ohio State University, died at Columbus, Ohio, Oct. 16th, in the seventieth year of his age. Professor Orton is chiefly known among scientific men by his contributions to Geology. Since 1865, he has been a resident of Ohio, and, while his labors have extended to all branches of geological science, his close watch of the exploitation of petroleum and natural gas, in his own and the neighboring States of Pennsylvania and Indiana, has given him a place of preeminence as interpreter of these important geological products. He took part in the preparation of volumes 1, 2 and 3, of the reports of the Geological Survey of the State of Ohio, and as State Geologist, issued volumes 4, 5, 6 and 7. He was appointed State Geologist in 1882, and has held that position up to the present year. In 1897, he was elected president of the Geological Society of America, and as president of the American Association for the Advancement of Science, presided at the recent meeting of the Association, in Columbus, in August last. Professor Orton was a man of broad culture and of influence outside his chosen science. Born at Deposit, Delaware Co., N. Y., he entered Hamilton College, graduating in 1848. He spent a year in the Lane Theological Seminary, and in 1852, took a course of studies in chemistry and botany at the Lawrence Scientific School. For three years he was professor of Natural Science in the State Normal School at Albany. He was for a time president of Antioch College, Yellow Springs, Ohio, and then became president of the Ohio Agricultural and Mechanical College, which has now become the State University. He resigned the presidency and became State Geologist in 1882. He was greatly beloved and esteemed by those who knew him. A fellow-townsman writes of him as follows: "In him were combined the deep thinking of the philosopher, the research of the scholar, the impulses of an honorable man, the manners of a gentleman, combined with infinite liberality, toleration and affability. As teacher, lecturer, college president and man he distinguished himself from his fellow-men without falling victim to the pride which too often goes hand in hand with greatness." Dr. Orton received the degree of Ph.D. from Hamilton College in 1848, and LL.D. from Ohio State University in 1881.



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(1) Described in this Journal Sept., 1895. (2) Ibid Nov., 1887. (3) Proc. Roch. Acad. Sci. Vol. I. (4) This Journal Aug., 1888. (5) Ibid July, 1893. (6) Ibid June, 1894. (7) Ibid Nov., 1892.

EDWIN E. HOWELL, 612 17th St., N. W., Washington, D. C.

DANA'S WORKS.

AMERICAN BOOK CO., New York.—**Manual of Geology,** by J. D. DANA. **Fourth Edition,** 1895. 1088 pp. 8vo. $5.00.—**Text-book of Geology** by the same. **5th ed.** revised by Wm. North Rice, 1898. 482 pp. 8vo. $2.00.—**The Geological Story Briefly Told,** by the same. 264 pp. 12mo.

J. WILEY & SONS, New York.—**System of Mineralogy** of J. D. DANA. 6th edit. by EDWARD S. DANA. lxiii, 1134 pp. large 8vo., 1892. $12.50. Appendix I, 75 pp., June 1899. $1.00. 5th edit., 1868, with three appendices, 1872, 1875, 1882. $5.00.—**Manual of Mineralogy & Lithology,** by J. D. DANA. 4th edition. 517 pp. 12mo., 1887, $2.00.—**Text-book of Mineralogy,** by E. S. DANA. Revised edition. 593 pp. 8vo., 1898, $4.00.—**Minerals and How to study them;** a book for beginners in Mineralogy, by E. S. DANA. 380 pp. 12mo., 1895, $1.50.—**Text-book of Elementary Mechanics,** by E. S. DANA. 300 pp. with numerous cuts, 12mo., 1881.

DODD & MEAD, New York.—**Corals and Coral Islands,** by J. D. DANA. 440 pp. 8vo. 3d ed., 1890.—**Characteristics of Volcanoes,** with contributions of facts and principles from the Hawaiian Islands, by J. D. DANA. 399 pp. 8vo, With illustrations, maps, etc. 1890.

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